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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXXV.—*Fossil Faunas and their use in correlating Geological Formations**; by HENRY S. WILLIAMS.

[By permission of the Director of the U. S. Geological Survey.]

IT has long been the practice of geologists to recognize fossils as the best available means of determining the systematic correlation of geological formations. And in making correlations by fossils it is probably true that the degree of likeness, expressed by numbers of identical species, is taken in general as the measure of the contemporaneity of the formations compared. As a means of gaining a rough approximation to contemporaneity this principle may be safely followed. The geological systems may thus be recognized in different parts of the world, and from comparisons of the faunas of the Paleozoic systems it has been estimated by the writer that a later and an earlier, and in some cases a middle division of the grand systems, can be distinguished throughout the known world by this method of interpretation of identity of species into contemporaneity. The plan of restricting uniformity of correlation, in an international scheme of classification, to systems and divisions of the systems to be indicated by the prefixes eo-, meso-, and neo- to the system name, is based upon this calculation.†

When, however, the attempt is made to correlate formations on a firm basis, and to trace or estimate the limits of local formations by means of fossils, some more accurate method than mere identity of species is demanded.

The reasons for this conclusion are various; among which is the fact that very many single species, whose range has been

* Read before the Connecticut Academy, Feb. 12, 1902.

† Journal of Geology, vol. ii, p. 157; Comptes Rendus, Congrès Geol. Internat., vii, cl and cli; Comptes Rendus, viii, p. 202.

established by thorough study of the successive formations in which they occur, range through a third and often a half of one of the standard geological systems.

With such a long range for the life period, it has been in some cases established that the variation between the earliest and latest known representatives of the species is not greater than the variation among representatives of the same species found buried together in the same stratum of rock. Having established such long range and such long persistence of specific characters, and associated with plasticity of the varietal characters for a few well studied species, it seems reasonable to infer that simple specific identity cannot be taken as proof of contemporaneity within narrower bounds than the life endurance of the species.

A second reason for not resting implicit confidence on this method of correlation is the frequently observed fact, that parts of the geological column of different sections, which upon satisfactory stratigraphic grounds are known to be stratigraphically equivalent, contain different fossils. If two such faunas were to be observed one above the other, the difference in fossils would be naturally interpreted as difference in time, while the fact of stratigraphic equivalency proves their contemporaneity. Since the non-identity of fossils is consistent with contemporaneity, the reverse is to be inferred, viz: that identity of fossils may be consistent with non-contemporaneity.

A third observation also may be cited against the principle: In a continuous section it is often the case that the topmost beds of one formation are followed abruptly, but without apparent unconformity, by the next following formation containing a majority of new species.

The abrupt change in the fossils, in such a case, cannot be taken as evidence of the total stopping of the old fauna or of the beginning of the new, but rather as the result of a shifting laterally of the conditions in which the faunas have lived, across the locality in which the sedimentation was made.

It is thus shown that a sufficient amount of doubt is thrown upon the reliability of simple identity of single fossils in determining equivalency of stratigraphic horizon (except in a broad sense) to call for a discussion of some more accurate method of correlation.

In the following pages is given a synopsis of the results of a prolonged series of investigations directed toward the discovery of the true time element in fossil faunas. It will be assumed that the reader is familiar with the distinction between a stratigraphic formation (which is a more or less uniform lithologic unit, and constitutes the thing which is represented

on a geologic map by a definite color, and is defined and discussed in literature under a definite name), and a fossil fauna (which is the aggregate of fossil remains representing once living animals which were associated together at the time of sedimentation of the formation in which they were buried). The geological column is made up of the successive formations, which would be exposed by a vertical section through any part of the earth's crust. In common usage the geological time-scale is constructed by applying chronologic terms, like age, period, epoch, etc., to the several formations of the geological column. The reference of each formation to its proper place in the scale, is established not by lithologic likeness but by faunal likeness. So far as common usage goes, the epochs or ages are the time equivalents of the formations and not of the faunas by which the time relations of the formations are established.

Further, it is a generally accepted belief that each geological formation occupies a definite place in such a theoretical time-scale. This belief carries with it the further conclusion that, if we determine the limits (below and above) of a given formation in the rocks of a particular locality, the recognition of the same formation in another section (fifty or a hundred miles distant, for instance) carries with it the inference that the second section of the formation represents the same interval of geological time.

These are ideas that constitute the working hypothesis of field geologists everywhere; and, although they may be applied as general, and not absolutely exact rules, they are used pretty commonly in what is called correlation. For instance, when the statement is made that the Independence Shales of Iowa are, or are not, equivalent to the Hamilton Formation,*—the meaning is that the formation which outcrops at Independence, Iowa, and specifically is named the "Independence shale," was, or was not, formed by deposition at the same time in which the Hamilton formation was forming over the area now called New York State.

Now the fact basis of that affirmation is not the recognition of the same constitution or thickness of the rocks in the two regions, but it is an opinion based solely upon the evidence of fossils occurring in the rocks.

The assumption, at the basis of the opinion, is that the fauna present in the rocks of the Hamilton formation represents a period of time which is recorded by the deposits of sediments called Hamilton in New York, and therefore that the same species seen in different regions can be relied on as evidence of the same portion of time.

* Iowa Geol. Survey, vol. viii, p. 205, etc., 1897.

Let us examine the validity of this assumption: Do divisions of the geological column, proven by paleontologic evidence to hold the same fauna, represent the same interval of time in different local sections?

An attempt was made to test this question in the case of the Catskill formation. A paper was written* in which it was demonstrated by comparison of sections in various parts of New York and Pennsylvania, that the sediments, which by lithologic, stratigraphic and paleontologic characters may be classified as a single formation, occupy a different systematic position in the geological column of areas a few hundred miles apart. In general, it was shown that when the time-scale is measured by the marine invertebrate faunas, the Catskill formation begins at the horizon of the Hamilton in the eastern sections and further west first appears at the horizon of the Ithaca or Portage, and in central and western New York and Pennsylvania does not appear till after the Chemung formation was well advanced. Nevertheless it could not be stated that the Catskill formation occupies the same place with the Chemung formation. For that would make the names partly or wholly synonymous.

It could not be stated that the Chemung is not antecedent in time to the Catskill when the formations are transformed into epochs, for that would mean that the two epochs are not distinct. So long as the formational nomenclature alone is used, the only way to state the facts is to say that the Catskill is not a good formation on account of its irregular position in the time-scale.

In Dana's Manual, last edition, the relation of the Chemung and Catskill on the basis of this interpretation is defined in the words: "They (these Catskill beds) are now believed to be a contemporaneous formation parallel in its deposition with that of the off-shore and deeper waters of the Chemung period, or Chemung and Hamilton periods, to the westward" (p. 576).

The fact is thus clearly brought out that the Catskill as a formation has as much title to recognition as the Hamilton or Chemung. So long as we have but one nomenclature, it is as reasonable to say that the Hamilton and Chemung belong to the Catskill period, as to give the latter prior place in the list of formations of the time-scale. But there are two sets of facts; and the real reason for the neglect of the Catskill formation in the time-scale is that its fauna is not as definite and significant as the fuller and more widespread marine faunas of the Hamilton and Chemung formations. The indefiniteness in its relation to a time-scale which was demonstrated for the Catskill formation, it is believed, is characteristic of all

* The Journal of Geology, vol. ii, pp. 145–160, 1894.

formations; and the facts are at hand to show that the actual limits of a fauna, when followed laterally with great care, so as not to lose track of the stratigraphic continuity, transgress the limit and run higher up as we cross the outcrops; and that it may be said with truth, that marine faunas of the same general nature, but of different place in the succession in any particular section, may lap over each other stratigraphically. These facts I have been able to demonstrate in respect to the relations of the faunas of the Devonian, which I and a number of geologists who have been trained to use the necessary precision in observing and reading the fossils, have brought to light. The result reached has been this, viz: the evidence is conclusive that the fauna of the Hamilton formation, which will be called the *Tropidoleptus fauna*, prevails in the rocks in eastern New York upward, beyond the place of the Genesee shales, to and beyond the interval occupied by the Ithaca formation of the Cayuga Lake section, and is seen in a few cases of definite, pure successional faunules up to the part of the section occupied by the Chemung formation, whose fauna may be called the *Spirifer disjunctus* fauna. This same interval, stratigraphically considered, is occupied by the Portage formation of the Genesee River Valley section, in which no trace of the Hamilton species and only slight trace of the species of the Ithaca formation are present, as determined by a careful search of the rocks from bottom to top.

In the elaboration of these facts it was necessary to form a nomenclature with which to handle the several different groups of facts for their discussion in relation to each other, to the element of time, and to the position in the structure scale.

Fauna and flora are terms well understood where only one point of time is considered; but where, in addition to the geographical distribution of species, we have also to deal with the geological range, it becomes essential to consider the fauna more exactly.

Geologically the element of evolution comes in, and a geological fauna is not only a set of species situated in or inhabiting a restricted geographical area: but geologically a fauna must be conceived of as changing its position, and as determined by the preservation of the equilibrium of the several species constituting it.

This equilibrium is expressed in terms of relative numbers and strength of the species of the fauna. In every aggregate of living species, the individuals of one species are abundant and vigorous in growth; others are less so but common; others still are rare and inconspicuous, while an occasional species is represented only by a very occasional specimen.

When a fauna is geologically considered, it is of first importance to note these characteristics, for by them we discover the relative dominance of the species in the faunal aggregate. And the dominant species, by the fact of being dominant, show that they have conquered the difficulties presented to their continuing life, and in the struggle for existence have thereby proven themselves to be the fittest to survive in the particular conditions they occupy. To express this characteristic of evolutional strength of an organism, the term *bionic* has been proposed. The term was defined in the following words:

"*The bionic quality of an organism may, then, be defined as its quality of continuing, and repeating in successive generations, the same morphologic characters.*"*

This quality of continuing and repeating the same morphologic characters is expressed in successive strata by the occurrence of the same fossil species; it is expressed geographically by the same species occurring in different geographic areas.

The relative *bionic values* of different species are expressed by the relative number of individuals in a faunal aggregate, and hence the equilibrium between the several species of a fauna is expressed in terms of the numbers of individuals of each species living together under a common set of conditions. Looking then at faunas from this bionic standpoint, we have a delicate test of the time relations of the faunas which is of extreme value in establishing correlations. For the integrity of a fauna expressed in terms of its dominant species can be conceived of as continuing only so long as the relative bionic values of each of the species remains constant. Any slight change of conditions, or incursion by migration of other species, may upset the bionic equilibrium, as will be expressed in terms of relative frequency of the constituent species of each faunule (that is, the local sample of the general fauna under consideration).

Having established this method of recording and measuring the time significance of a fossil fauna, its use in making correlations becomes evident. We have here a means of distinguishing the effects of change of geographic conditions (viz: geographical distribution) from change coincident with passage of time (viz: geologic range).

In the same section we may discover, by noting the bionic values of the successive faunules, how long the integrity of the fauna is preserved, and whether any evolution of species takes place during that life period of the fauna. So long as the same species continue to be the dominant species in the successive faunules, the faunal integrity is preserved. When

* "The discrimination of time-values in geology." Journ. Geol., vol. ix, p. 578.

the dominant species are permanently replaced by other species, the change in fauna has become apparent. This can be observed, although in the meantime there may have appeared faunules of entirely different composition intercalated between successive stages of the prevailing fauna.

Again, the distribution of the fauna becomes at once evident when we deal with the dominant species in sufficient number to represent the fauna in its characteristic expression.

The testing of this method has been carried out in detail by the United States Geological Survey in the study of the Devonian faunas, of which, I believe, we have now a fuller set of statistics illustrating this law than of any other system in the whole geological column. The statistics have been worked out regarding these faunas to a degree which enables us to give figures, and state definite results of correlation.

The Hamilton formation has been carefully studied by many workers, but only within a few years have the statistics been brought out with sufficient precision to make them available for the determination of the bionic values of the several species of the fauna. The fauna of the Hamilton formation of New York State is called the *Tropidoleptus fauna;* the fauna of the typical Chemung formation is the *Spirifer disjunctus fauna*; the fauna of a zone intermediate between them in central New York is the *Productella speciosa fauna*, and the zone is generally known as the Ithaca formation. The relative position of the Hamilton, Ithaca and Chemung formations is well established on stratigraphic grounds; but the correlation of the formations is not so clearly understood. The bionic method makes it possible to say that the Tropidoleptus fauna lived on in the eastern New York area till after the Spirifer disjunctus stage had been reached in the western part of New York state. To establish these facts the statistics of 146 local faunules of the Hamilton formation in eastern New York and Pennsylvania have been examined, gathered chiefly by Prof. C. S. Prosser.* Faunules from 76 zones examined in the 1224 feet of section of the Hamilton formation at Cayuga Lake, made and tabulated by Dr. H. F. Cleland, and reduced to 25 temporary stages of the faunal history, were studied.† The Eighteen Mile Creek section worked out by Mr. Grabau‡

* Classification and distribution of the Hamilton and Chemung series of central and eastern New York. 15th and 17th Ann. Repts. State Geologist, N. Y., 1895 and 1900. The Devonian System of Eastern Pennsylvania and New York. Bull. 120, U. S. G. S., 1894.

† A study of the fossil faunules in the Hamilton formation of the Cayuga Lake section in central New York. A Thesis for Doctor of Philosophy degree (given by Yale University in 1900), by Herdman F. Cleland.

‡ The faunas of the Hamilton Group of Eighteen Mile Creek and vicinity, in western New York, by Amadeus W. Grabau. 16th Ann. Rept. of State Geologist, N. Y., 1898.

have yielded 35 separate zones, of which the faunules have been accurately noted.

The number of species in the first set of statistics is 172; in the second 234; and in the third 163. In the first set of statistics the geographically dominant species are ascertained. A list of 12 species is derived which are reported from over 32 of the 146 localities examined—the five more dominant ones are from over 50 of the 146 localities. When the localities are grouped in 5's lying most nearly together, so as to eliminate the imperfection of the collecting, the best 5 of the 12 species occur in 26 out of 30 of these groups of localities; and all the 12 species of the dominant list occur in 17 out of the 30 groups. The evidence is clear that we have in such a list the species which possessed the highest bionic value in distribution.

The list in order of dominance is as follows:

	A	*B*	*C*	*D*
1. Spirifer pennatus (Atw.)	113	30	26	33
2. Tropidoleptus carinatus	89	27	22	30
3. Spirifer granulosus	59	28	11	15
4. Chonetes coronata	57	26	10	16
5. Palæoneilo constricta	56	27	2	5
6. Nucula bellistriata	42	23	4	8
7. Ambocœlia umbonata	40	22	4	8
8. Nuculites triqueter	38	22	1	7
9. N. oblongatus	35	21	1	3
10. Nucula corbuliformis	33	17	4	3
11. Athyris spiriferoides	32	24	2	5
12. Phacops rana	32	18	1	4

A—number of times in the 146 faunules;
B—number of times in 30 groups of 5 faunules each;
C—number of times marked abundant (*a*), and
D—number of times marked common (*c*).

The figures in the columns to the right signify that the first four species of the list are decidedly the more abundant in individuals, in the faunules, as shown by the figures in the fourth and fifth columns. This list, then, gives us the expression of bionic dominance in distribution and frequency in the faunas of eastern New York and Pennsylvania.

The analysis of the Cayuga Lake and Eighteen Mile Creek faunules will give the range-bionic values. Fourteen species out of the 234 were found to be dominant in being the more frequently represented (all of them 16 or more times) in the 25 successive zones; 9 of this list are also in the dominant list, based on geographical distribution and frequency in the eastern area.

Analysis of the Eighteen Mile Creek statistics shows that there is a list of 12 species which are in 14 or more of the 35

zones distinguished by Mr. Grabau; 12 out of a total of 163 named species. Of these 12 species dominant in range at Eighteen Mile Creek only four are in the first list. There is evidently a change in the composition of the fauna on passing westward across New York state.

Taking these lists thus obtained, expressing the bionic values of the species of highest rank in the several faunas, a table of standard dominant species of the Tropidoleptus fauna may be compiled. In forming such a table the following three particulars are used in discriminating the bionic strength of the species, viz:

I. Geographic frequency of occurrence in 146 sample collections (faunules) of the Hamilton formation in eastern New York and Pennsylvania;

II. Frequency of recurrence vertically in 25 zones of the whole Hamilton section of Cayuga Lake section in central New York;

III. Frequency of recurrence in 35 zones of the Eighteen Mile Creek section of the Hamilton formation in western New York.

The lists of species, to the extent of 12 to 15 in number, presenting the highest bionic value in each of the three cases, were compared on the basis of their relative bionic values, the averages obtained and the 12 species presenting the highest total values are given in the following list, with the values reduced to percentage in relation to highest possible bionic value. The highest possible bionic value, or 100 per cent, would be expressed by representation of the species in every one of the sample faunules examined for each case.

The species of the list are, thus, those showing the greatest bionic power of endurance in geographic distribution and in geologic range for the region and range under consideration.

Tropidoleptus fauna.

Standard list of dominant species for the New York-Ontario Province, with bionic values of species expressed in percentage.

1.	Spirifer pennatus	79%
2.	Phacops rana	58
3.	Tropidoleptus carinatus	56
4.	Amboccelia umbonata	54
5.	Athyris spiriferoides	47
6.	Palæoneilo constricta	45
7.	Spirifer granulosus	36
8.	Chonetes coronata	36
9.	Nuculites triqueter	33
10.	Nucula corbuliformis	33
11.	Nuculites oblongatus	31
12.	Nucula bellistriata	20

The first ten species of this list exhibit, by the method used in measuring them, a bionic value of 33 per cent and over in the fauna to which they belong, and, therefore, they may be regarded as the characteristic species of the fauna for the region examined. They maintain their position of bionic dominance, geographically, over the eastern half of New York and down into Pennsylvania; and geologically, throughout over a thousand feet of thickness of sediments called the Hamilton formation.

The introduction of evidence from other faunules of the same region slightly modifies the percentages, but the differences are not greater than might be expected from the imperfection of the statistics themselves.

For instance, I have examined another group of 37 faunules from the Unadilla region, recorded by Prosser.* In a list of the ten species with highest bionic index, are eight of the standard list. If they are incorporated with the eastern faunules already tabulated, the result is the same for the first twelve of the resulting list, based upon the total (146+37 =) 183 faunules.

The Hamilton species from Ontario, Canada, given by Whiteaves in his revised list† includes eight of the twelve dominant species of our list, but the facts of abundance, rarity, or frequency are not noted by Whiteaves, hence the actual bionic relations of the species cannot be stated.

Among the few species recorded by Rominger‡ as occurring in the Michigan area are named five of the standard list.

In the list of species from Milwaukee, recorded by Teller & Monroe,§ are named four of the standard ten.

In Mr. Weller's list of species for southern Illinois‖ are mentioned three of the standard ten species.

In Indiana, Dr. Kindle¶ has recorded from the Sellersburg faunule three of the standard list.

The Iowa Devonian lists show only a single species of the standard dominant species of the fauna (viz: *Phacops rana*), and the Devonian of Manitoba, Saskatchewan and McKenzie River regions, which has been studied by Dr. Whiteaves,** shows not a single species of the typical list.

* The Devonian section of central New York along the Unadilla River. 46th Ann. Rept., N. Y. State Museum, pp. 256–288, 1893.

† Revised list of the fossils of the Hamilton formation of Ontario, Geol. Surv. Canada, Contrib. Can. Paleontology, vol. i, p. 412, 1898.

‡ Geol. Surv. Michigan, vol. iii, pp. 38 and 63. 1873–1876.

§ Jour. Geol., vol. vii, pp. 272-283, 1899.

‖ Jour. Geol., vol. v, pp. 625–635, 1897.

¶ 25th Ann. Rept. Dept. Geol., etc., Indiana, pp. 530–775.

** Geol. Surv. Canada; Contr. Canadian Paleontology, vol. i, pts. iii and iv, 1891 and 1892.

A manuscript catalogue, furnished me by Prof. Prosser for the western Maryland region which he is now working up, contains every one of the standard list of ten—there are 132 entries.

On the basis of these facts it is evident that there is a limited geographical extension of the fauna; as we follow it southward west of the Cincinnati anticlinal, it becomes considerably modified; the Iowan area and the northern extension of the Devonian across central British America neither contain the Tropidoleptus fauna, although they do contain a fauna which is believed to be of Meso-Devonian age. The affinities of the Meso-Devonian faunas in Iowa and the Manitoba-Saskatchewan region (as I have previously suggested*) are more closely akin with the European Devonian than with the Tropidoleptus fauna, which is distributed along the Appalachian trough and as far around as into the Michigan embayment, and (which is of much more interest) is also conspicuous among the Devonian faunas of South America.

Knowing then what are the characteristics of the Tropidoleptus fauna in its typical region in North America, its presence may be recognized by the dominance of the dominant species, or several of them associated together. By this test we discover that, although the Productella speciosa fauna is quite distinct from it and is known to follow, by several hundred feet, the top of the Hamilton formation of Cayuga Lake, its time-equivalence is with the later life period of the Tropidoleptus fauna.

This is shown by the fact that the faunules occurring at the same horizon in the eastern part of the state maintain the bionic equilibrium peculiar to the Tropidoleptus fauna; and by the second fact that above the typical Ithaca formation, in the midst of the Spirifer disjunctus fauna, occur faunules in which the dominant characteristics of the Tropidoleptus fauna are still found associated with species not found either below in the Hamilton formation of that meridian or in the Tropidoleptus fauna in its metropolis area.

The details of these facts have been more fully elaborated by Dr. E. M. Kindle since my own statements regarding the general facts were stated.†

In Dr. Kindle's list of the species of the Ithaca formation, based upon the analysis of 54 faunules, not a single species of the ten standard list species of the Tropidoleptus fauna appears until we reach the thirteenth species in rank of the Ithaca list; and the second one is nineteenth in bionic rank in the Ithaca list. This shows plainly that the Productella fauna is not

* Proc. A. A. A. S., xli, p. 169.

† Bull. 3, U. S. Geol. Surv., 1884; Bull. 6, Am. Paleontology, 1896.

the Tropidoleptus fauna although there are a considerable number of so-called Hamilton species in the Ithaca formation. As this latter formation is traced eastward, however, the species of the Tropidoleptus fauna increase in it, and the dominant Tropidoleptus species take higher bionic rank; so that the fauna of the Ithaca formation, in its eastern extension, contains two of the standard dominant species of the Hamilton formation among its twelve dominant species as evidenced by 67 faunules.

That this Productella fauna is actually distinct and younger than the Tropidoleptus fauna is shown by the fact that there are 21 species in it which are characteristic of the Ithaca formation at Ithaca which is known to be above (by several hundred feet) the top of the Hamilton formation and Genesee shale. These 21 species are not known to occur in the Hamilton formation in any of its exposures; and among them are seven of the ten most dominant species of the Ithaca formation.

If a step be taken further westward, it is known that the total sediments (of some 1000 feet thickness) from the top of the Genesee to the true Chemung, with its Spirifer disjunctus fauna, in the Genesee valley, contain none of the dominant species of either the Hamilton or Ithaca formations; I refer to the typical Portage formation.

Again, we have positive evidence of a colony of the Tropidoleptus fauna within at least fifty feet of the typical horizon of the Chemung formation in Chemung County; and also in the midst of the Chemung or Spirifer disjunctus fauna at Owego, as I announced in 1884.*

These evidences of the Tropidoleptus fauna are so clear that if we were to find them in an isolated region, no hesitation would be taken to calling the formation holding them Hamilton, except that a few species of much later age are associated with them.

The typical species of the Tropidoleptus fauna are such as

Tropidoleptus carinatus abundant,
Ambocœlia umbonata "
Phacops rana rare but with several specimens.

It also contains such characteristic species as

Spirifer marcyi, and probably *S. granulosus*,
Cypricardella bellistriata,
Goniophora hamiltonensis,
Macrodon hamiltoniæ,
Loxonema delphicola, and
Modiomorpha mytiloides.

* Bull. 3, U. S. Geol. Survey, p. 24, 1884; also Proc. A. A. A. S., xxxiv, p. 226, 1886,—this is the stage A^6+ of the Tropidoleptus fauna, called in that paper Middle Devonian fauna A; also p. 230.

The faunule from Owego, to which I made reference in my papers of 1884 and 1886, was so characteristically Hamiltonian in its species that at that time it was difficult to believe that the zone in which it occurred was not out of place. But the recent rediscovery of the zone at Waverly by Dr. Kindle, and a comparison of the forms, leaves no doubt as to the actual position of the recurrent Hamilton faunule in the midst of the Chemung formation. The species of this faunule are given in the following list.

$\frac{1130}{A}$. Recurrent Tropidoleptus fauna from Cemetery Hill, Owego, Tioga Co., on side hill above, and southeast of the old Erie depot, collected by H. S. Williams (U. S. G. S. station 1130 A).

1.	*Spirifer marcyi* var.	*aa*	Hamilton
2.	*Ambocœlia umbonata*	*aa*	Marcellus-Chemung
3.	*Cypricardella bellistriata*	*aa*	Hamilton
4.	*Tropidoleptus carinatus*	*c*	Hamilton
5.	*Leiopteria bigsbyi*	*c*	Hamilton
6.	*Phacops rana*	*r*	Hamilton
7.	*Productella speciosa*	*r*	Portage-Chemung-Kinderhook
8.	*Coleolus acicula*	*r*	Genesee
9.	*Loxonema delphicola*	*r*	Hamilton
10.	*Camarotœchia* cf. *prolifica*	*r*	Marcellus-Hamilton
11.	*Goniophora hamiltonensis*	*r*	Hamilton
12.	*Modiomorpha mytiloides*	*r*	Hamilton
13.	*Spirifer* cf. *granulosus*	*rr*	Hamilton
14.	*Chonetes setigera*	*rr*	Marcellus-Waverly
15.	*C. lepida*	*rr*	Marcellus-Chemung
16.	*Macrodon hamiltoniæ*	*rr*	Hamilton
17.	*Lingula* sp.	*rr*	----
18.	*Pterinea* sp.	*rr*	----
19.	*Grammysia* sp.	*rr*	----
20.	*Palœoneilo* sp.	*rr*	----
21.	*Aviculopecten* sp.	*rr*	----

It will be observed that of the sixteen species, specifically identified, all but two are Hamilton species. One of the exceptions is *Productella speciosa*, which has been reported from Portage, Chemung and Kinderhook formations, and the other, *Coleolus acicula*, is a Genesee species. Eleven of the sixteen have not been hitherto reported from above the Hamilton formation; while the other four range both below and above that formation.

On the principle of specific identification, therefore, this faunule belongs to the genuine Tropidoleptus carinatus fauna, of which it contains four of the dominant species of the standard list.

The species of the Waverly fauna, collected and identified by Dr. Kindle, are as follows, viz:

$\frac{1462}{B}$. Tropidoleptus faunule as a colony in Chemung formation, Waverly, N. Y. 1462 B, (U. S. G. S.,) identified by E. M. Kindle (1902).

1.	*Tropidoleptus carinatus*	*a*	Hamilton
2.	*Ambocœlia umbonata*	*a*	Marcellus-Chemung
3.	*Rhipidomella vanuxemi*	*c*	Cornif.-Hamilton
4.	*Spirifer marcyi*	*c*	Hamilton
5.	*Cypricardella bellistriata*	*c*	Hamilton
6.	*Productella lachrymosa*	*c*	Chemung
7.	*Delthyris mesacostalis*	*c*	Ith.-Chemung
8.	*Camarotœchia contracta*	*r*	Portage-Waverly
9.	*Schizophoria* cf. *tioga*	*rr*	Portage-Chemung
10.	*Leptodesma matheri*	*rr*	Chemung
11.	*Glyptodesma erectum*	*rr*	Hamilton
12.	*Pterinopecten* sp.	*rr*	
13.	*P. crenicostatus*	*rr*	Chemung
14.	*Modiomorpha* cf. *concentrica*	*rr*	Hamilton
15.	*Cyrtina hamiltonensis*	*rr*	Up. Held., Ham., Ptg., Chem.

The commonly reported range by formations is given in the column on the right.

In this faunule, it will be observed, the abundant and common forms are, with the exception of Productella, chiefly found in the Hamilton formation.

Nevertheless the faunule occurs in the rocks after the Spirifer disjunctus fauna has occupied the region in force with its typical development; thus showing that in time the two faunas were coexistent in separate areas in their normal bionic strength. That is to say, in the areas of their geographic metropolis, each fauna maintains its bionic equilibrium as expressed in frequency and dominance of species.

The importance of this case of recurrence of the Tropidoleptus fauna is so great as to call for every precaution as to its verity. The intrinsic evidence of its Chemung horizon was not present in the Owego faunule. There are no species there which might not occur as low as the Ithaca Group. But the faunule collected at Waverly contains *Delthyris mesacostalis* with a distinctly strong median septum, which is wanting or very slightly developed in the specimens of the Ithaca formation; also a single specimen of *Schizophoria tioga*, nothing like which is known in the typical fauna of the Ithaca formation. The *Productella lachrymosa* is not so strongly of the true lachrymosa type as to make it certain that it may not be an extreme variation of *Productella speciosa*. The Leptodesmas

are so variable that the form *L. matheri* is not conclusive of post-Ithaca stage.

In my collections from the Waverly-Chemung cliffs, however, Tropidoleptus was discovered above the first appearance of *Spirifer disjunctus* and other typical members of the Spirifer disjunctus fauna. These facts are intrinsic evidence, therefore, that the combination of species, so much like the typical Tropidoleptus carinatus fauna of the Hamilton, is here present in a part of the rock section occupied in general by a typical Spirifer disjunctus fauna.

The fact that the combination of species is the normal combination seen in the undisputed Hamilton formation shows that its equilibrium has not been disturbed and, therefore, that the life history of the fauna of the Hamilton formation has not ceased; while the faunas above and below in the cliffs in Chemung narrows is evidence that the geological horizon is that of the typical Chemung formation. The lapping of faunas of the same kind seems to be established by evidence beyond dispute, and correlations must be made with recognition of such a possibility in cases where the direct evidence of the fact may be wanting.

When we attempt to correlate formations with this knowledge before us, it is evident that the life period of a fauna is not what it appears to be in any particular section. Whenever the succession is sharply defined by the stopping of one fauna and the abrupt beginning of another, in full or decided strength, the evidence should be interpreted as positive that the boundary between the two consecutive formations does not make the end of one fauna and the beginning of the succeeding one. It is to be interpreted rather as only a well advanced stage into the later one, and the vigorous period of persistence of the other. This, interpreted into comparative terms, would result in showing that the two faunas lap over each other in time.

My studies convince me that this is frequently the case in respect to the boundary lines of our formations. The abrupt transition from one formation to another with a different fauna is convincing evidence that the abruptness of the change in fossils is due either to absence of strata (i. e., an apparent or concealed unconformity) or else to migration of the faunas across the area.

This principle must be recognized in making correlation, if we would reach correct interpretation of the facts.

The laws discovered in the statistics above reported may be summarized as follows:

A *geological fauna* may be defined as an aggregation of species living together, the several species of which hold a definite value in relation to each other.

The relative value of the constituent species is expressed in terms of the abundance or rarity of the individuals of each faunule sample, viz: *bionic value.*

The purity or integrity of the fauna may be recognized by the list of its *dominant species.*

The *geographical distribution* of the fauna may be recognized by the presence of the dominant species and their holding their standard dominance in the list of species with which they are associated in the faunule.

The region, over which the bionic equilibrium of the fauna is expressed by occurrence of the same dominant species, is the *metropolis of the fauna.*

The *geological range* of a fauna is recognized by the persistence of the bionic equilibrium of the species.

Two faunas may coexist in time in distinct geographical areas; but in the same area, the two faunas can appear in their integrity only by displacement by which the bionic equilibrium will be disturbed. Hence two faunas in their purity will always appear in succession in any single section.

As the geological changes are, in general, in one direction for any particular region, the *shifting of faunas* is likely to be in the same direction for long periods of time, and thus the recurrence of two distinct faunas is rare. Occasionally oscillation of two faunas can be recognized in a single section this fact may be interpreted as migration back and forth over the same region. The occurrence of two faunas each occupying a distinct metropolis will thus rarely ever show itself in lapping of the faunas; but occasionally evidence of the coexistence of the faunas will be seen in the intercalation of a colony of one of the faunas in the midst of the other. The *lapping of faunas*, stratigraphically, is the necessary interpretation of the coexistence of two faunas at the same period of time.

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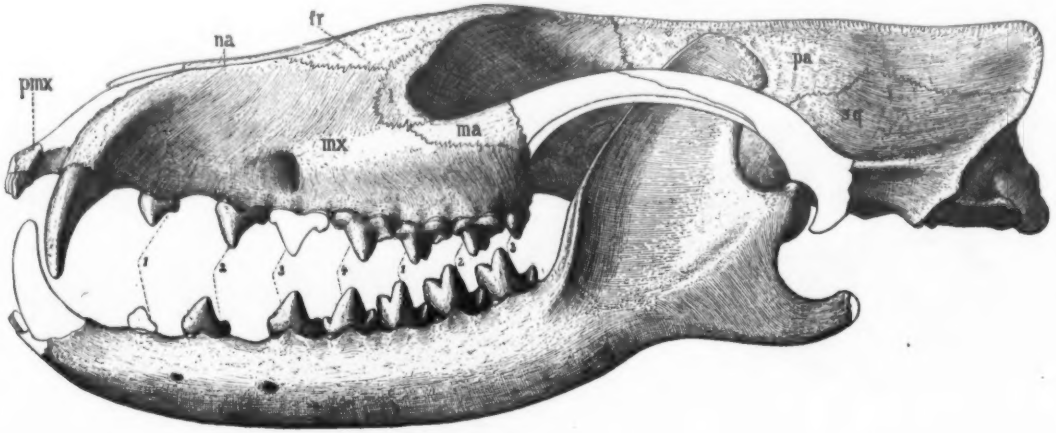
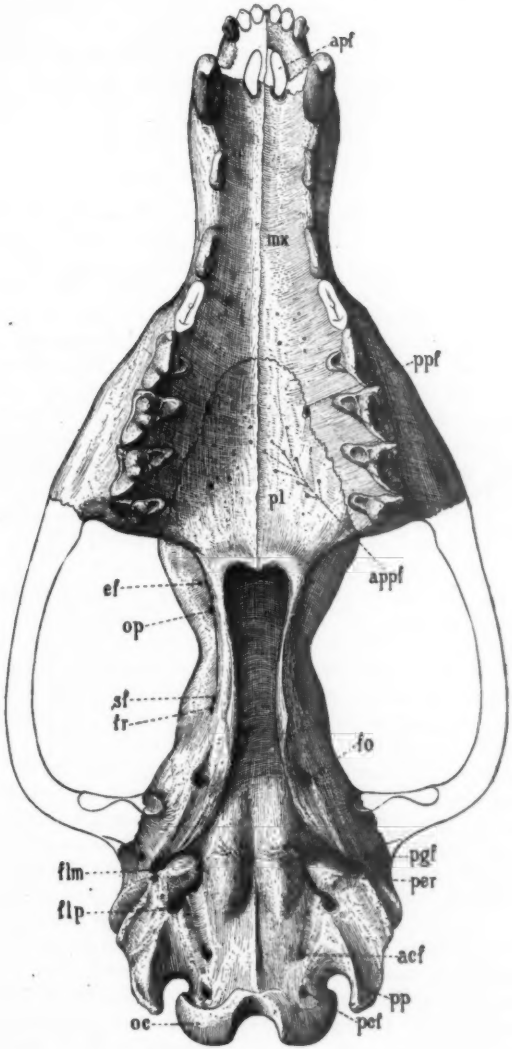


EXPLANATION OF PLATE VII.

Skull of *Sinopa agilis* Marsh ; side view ; natural size ; combination of the type and another specimen in the collection.
pa, parietal ; *sq*, squamosal ; *ma*, malar ; *mx*, maxillary ; *l*, lachrymal ; *fr*, frontal ; *na*, nasal ; *pmx*, premaxilla.

Am. Jour. Sci., Vol. XIII, 1902.



EXPLANATION OF PLATE VIII.

Skull of *Sinopa agilis* Marsh; inferior view; natural size; combination of the type and another specimen in the collection.

apf, anterior palatine foramen; *ppf*, posterior palatine foramen; *appf*, accessory postpalatine foramina; *fo*, foramen ovale; *pgf*, postglenoid foramen; *per*, periotic; *acf*, anterior condyloid foramen; *pp*, paroccipital process; *pcf*, posterior condyloid foramen; *oc*, occipital condyle; *flp*, foramen lacerum posterius; *flm*, foramen lacerum medius; *fr*, foramen rotundum; *sf*, sphenoidal fissure; *op*, optic foramen; *ef*, ethmoidal foramen; *pl*, palatine; *mx*, maxillary.

ART. XXXVI.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN. (With Plates VII and VIII.)

[Continued from p. 206.]

Family *Hyænodontidæ*.

STILL another group of the Creodonta is the family Hyænodontidæ, which, like so many representatives of the Carnivora already noticed, appears suddenly in the lower stages of the Middle Eocene or Wasatch deposits, without any previous announcement in the way of ancestors in the underlying Torrejon. The present association of the genera in this family is very different from that adopted by Cope, Scott, and Schlosser. For example, Cope placed *Hyænodon* by itself in a separate and distinct family; *Pterodon* was arranged in the Oxyænidæ; while *Sinopa* (*Stypolophus*), *Proviverra*, *Quercytherium*, and *Didelphodus* were classified in the family Leptictidæ. Both Scott and Schlosser arranged *Oxyæna*, *Protopsalis*, *Hemipsalodon*, *Pterodon*, *Dasyurodon*, *Thereutherium*, and *Hyænodon*, in the family Hyænodontidæ, at the same time placing *Patriofelis* in the Palæonictidæ. The genera *Sinopa*, *Proviverra*, *Quercytherium*, and *Didelphodus* were placed by them in a distinct family, Proviverridæ. The first important advance over this arrangement of the genera into family groups was made in 1894,* when I pointed out that *Oxyæna* and *Patriofelis* are nearly related types, and should be classified in the same family; that *Protopsalis* is probably the same as *Patriofelis;* that neither of these genera is closely related to *Hyænodon;* but that *Hyænodon* and *Sinopa* (*Stypolophus*) are closely related to each other. In the same year, Osborn and myself added *Pterodon* to the two last-mentioned genera, from a consideration of the teeth.† The close relationship of *Proviverra*, *Cynohyænodon*, and *Quercytherium*, to *Sinopa*, was then well known, and the inference was clear that these forms follow *Sinopa* wherever placed in the classification. In further elaboration of these views, I published in 1899‡ a brief classification of the three families Hyænodontidæ, Oxyænidæ, and Palæonictidæ, which, I may add, forms the basis of our present understanding of the arrangement of these three important groups of the Carnivora.

As regards the definition of the Hyænodontidæ, if we leave out of consideration *Palæosinopa* and *Didelphodus*, which more probably are members of the Insectivora rather than of the Creo-

* Bull. Amer. Mus. Nat. Hist., 1894, pp. 152, 156. † Ibid., 1894, p. 237.
‡ Ibid., 1899, pp. 139, 140.

donta, we shall have little difficulty in distinguishing it from the Oxyclænidæ on the one hand, and the Oxyænidæ on the other. In the former of these families, none of the superior molars are of a pronounced shearing type, but seem (according to Matthew) to have been tending more in the direction of a tubercular than of a sectorial structure.* From the Oxyænidæ the family under discussion may be distinguished by the circumstance that it is the *second molar* above and the *third molar* below that were becoming the most specialized carnassials; whereas, in the Oxyænidæ, it was the *first molar* above and the *second molar* below that were thus specialized. In the Carnassidentia, as I have pointed out on a former page (337), the axis of sectorial development has shifted still further forward, and involves the *fourth premolar* above and the *first molar* below. Another important dental character of this family is the comparatively small size and weak development of the first molar below and frequently of the corresponding tooth above as well. This is a conspicuous feature of all the later species, particularly those of *Hyænodon* and *Pterodon*, and is also seen in nearly all species of *Sinopa*, although less strongly marked.

The progressive characters of the teeth consist in the gradual loss of the internal cusps of the superior molars, the complete fusion of their primary external cusps, and the loss of the third molar. In the inferior molars, the heels or talons decrease in size and disappear, and the internal cusp of the trigon becomes rudimental or wanting.

Sinopa Leidy.

Sinopa Leidy, Proc. Acad. Nat. Sci., Phila., 1871, p. 115;
Stypolophus Cope, Pal. Bull., No. 2, Proc. Amer. Philos. Soc., 1872, p. 446;
Prototomus Cope, Report on Fossil Vert. N. M., Ann. Rept. U. S. G. S. W. of 100th Mer., 1874;
Limnocyon Marsh, in part, this Journal, 1872, p. 122.

The only genus of the family thus far known to be represented in the Bridger fauna is *Sinopa*, described by Leidy from the lower part of the horizon in 1871. It first appears in the beginning of the Middle Eocene or Wasatch, and is represented by at least six fairly distinct specific modifications in these beds. One very well known species comes from the Wind River beds, while at least four are now known from the Bridger. The definition of the genus is as follows:

A group of small or medium-sized Creodonts, with a complete dentition, having the superior molars with well-developed internal

* There is as yet no evidence sufficient to determine the position of this group satisfactorily. They have always been assumed to be Placentals, and have been placed among the Creodonts. They may quite as well be Implacentals, as far as any very good evidence to the contrary is concerned, or they may prove to be Insectivores, with numerous transitional or Implacental Metatherian characters.

cusps, more or less fused or well-separated external cusps, and with anterior and posterior external angles produced into shearing blades; with first premolar above, and first and frequently second below, spaced; with first lower molar more or less reduced, and becoming progressively smaller and weaker than the others; and with pentadactyle limbs, in which the ungual phalanges are compressed, curved, and sharp-pointed.

Sinopa rapax Leidy.

Sinopa rapax Leidy, Proc. Acad. Nat. Sci. Phila., 1871, p. 115;
Stypolophus pungens Cope, Proc. Amer. Philos. Soc., 1872, p. 446.

The type species of this genus was described from a lower jaw fragment, carrying the fourth premolar and first molar in good condition, together with the heel of the second and the roots of the third. The specimen, although fragmentary, was well described and figured by Leidy, and it is possible to refer other material to it from the same horizon. Cope in speaking of his genus *Stypolophus* says:* "Dr. Leidy has applied the name *Sinopa* to some flesh-eaters of the Bridger epoch without distinctive generic description. An examination of the typical specimen of the *S. vorax* [*rapax*], which Dr. Leidy kindly

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FIGURE 83.—Lower jaw of *Sinopa rapax* Leidy; side view; natural size.

permitted me, shows that it differs from *Stypolophus* in the rudimental character of the heel of the last molar, if the specimen is not deceptive. It is otherwise identical in the last four inferior molars." Now Leidy's specimen is deficient in the matter of the last molar, and it is not possible, according to his figure, to make out anything concerning the crown more than what is stated in the description, which is as follows:† "The last molar is a two-fanged tooth like those in advance, but is not quite so wide, and a small portion of the back of the crown indicates it to have been of less thickness."

There are two specimens in the Marsh collection, consisting of considerable portions of the mandibular rami. One is a

* Tertiary Vertebrata, 1884, p. 289.
† Extinct Vertebrate Fauna of the Territories, 1873, p. 116.

right lower jaw of a young adult, figures 83, 84, containing all the molars and the three posterior premolars, in an almost perfect condition. The second specimen is more fragmentary, but the anterior portion of the ramus is sufficiently preserved to show the roots of the anterior premolars and the canine.

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FIGURE 84.—*Sinopa rapax* Leidy; crown view of three lower molars; natural size.

The teeth agree so perfectly, both in measurements and structure, with Leidy's type of *S. rapax*, that I do not hesitate to refer them to this species. Containing, as they do, almost the entire lower dentition, including the last two molars, it is possible to compare them with Cope's type of *Stypolophus pungens*, which is also a jaw fragment carrying the second and third molars. The Marsh specimens agree quite as well with the Cope specimen as with that of Leidy, from which it is evident that all refer to one and the same species. I therefore unite them under Leidy's name *Sinopa rapax*.

The characters of the species, as revealed by these specimens, are as follows: The first lower premolar is single-rooted and separated from the canine and second premolar by short diastemata; the second, third, and fourth are not spaced, but are in contact; the first molar is the smallest and the second is slightly larger than the third; the trigon of the first molar is considerably less elevated than that of either the second or third; the heels of the molars are relatively wide and basin-shaped, that of the third or last being noticeably smaller and narrower than the others; the edge of the rim surrounding the heel is interrupted on its postero-external border by a moderately deep notch, which, when seen from the outside, gives the heel the appearance of being bicusped.

There is also in the collection a fragment of an upper jaw, which includes the fourth superior premolar somewhat damaged and the first and second molars in fairly good condition. I place the specimen in this category more by exclusion than by any real evidence which it exhibits. The size of the teeth corresponds very well with those of the lower jaw, and they display just such characters as we should expect to accompany the lower series above described. Their chief characters are the following: The fourth premolar has a large internal cusp and a well-developed blade-like postero-external cusp; the first and second molars are subequal, the internal cusps are relatively large and lunate, the two primary external cusps are well separated, and the antero-external angle of the second is not produced into a cutting blade. I give the following principal measurements:

Length of inferior molar and premolar series from base of canine	55·mm
Length of premolars	32·
Length of molars	23·
Depth of jaw at second molar	18·
Length of fourth superior premolar and first and second molars	23·
Width of first molar	7·
Width of second molar	9·

The more perfect of the lower jaws was found by Professor Marsh, at Grizzly Buttes, where Dr. Leidy's type was collected. No locality is given on the labels for the other two specimens.

Sinopa agilis Marsh.

Limnocyon agilis Marsh, this Journal, 1872, vol. iv, p. 202;
Stypolophus brevicalcaratus Cope, Proc. Amer. Philos. Soc., 1872, p. 469.

The materials from which this species was originally described consist of the larger part of the skeleton of a young individual, somewhat crushed. There are represented numerous vertebræ, ribs, limb bones, an almost complete fore foot, and considerable portions of the skull, with nearly the entire dentition. Fortunately, this specimen is supplemented by a second skeleton of a somewhat older individual, in which the skull is very well preserved, but the teeth are considerably worn. This specimen also includes numerous parts of the remainder of the skeleton, so that between the two a very accurate understanding of the osteological structure may be had. Upon the most careful comparison, there is no doubt of the specific identity of the two specimens, and I have accordingly not hesitated to use all the skull material in the restoration of the skull represented in the accompanying plates, VII, VIII.

The Skull.—The general appearance of the skull is not unlike that of many living Carnivores, exhibiting an unusually narrow, elongate type, with a remarkably straight, superior outline, and with crests and arches of moderate proportions. The skull, as a whole, is much smaller in proportion to the rest of the skeleton than is usually the case among the Creodonts. In length, it holds nearly the same relation to the tibia and humerus as that seen in *Herpestes*, and, except for the length of the face in *Sinopa*, the other proportions are not very different. This feature gives the skeleton a much more modern appearance than many of its contemporaries. The brain case is exceptionally long and narrow, the postorbital constriction, which is well marked, being placed a little posterior to the middle of the cranium. The facial portion is not unlike that of some of the Canidæ, relatively long and narrow, with a considerable constriction posterior to the roots of the

canines. The nasals, of which the extreme anterior portions are missing, are narrower in front than behind, as in the carnivorous Marsupials, although the posterior widening is not nearly so marked as in this group. They terminate posteriorly in a pointed extremity, which is situated near the center of an unusually broad and deep frontal depression. The nasals are not so wide posteriorly as to restrict the contact between the frontals and maxillaries, as is the case in certain of the carnivorous Marsupials, and in *Dromocyon* already described, so that this feature of the skull is decidedly more Carnassident in appearance. The maxillary is large and has a form common to the carnivorous skull. The posterior suborbital region, however, is exceptionally broad, and is in every way more extensive and primitive looking than in any of the Carnassidents. Owing to the large facial development of the lachrymal, the maxillary lacks considerable of reaching the rim of the orbit. The infraorbital foramen is of goodly size, and issues a short distance above the hinder edge of the third premolar, about as in the fox. As already stated, the lachrymal is relatively large and spread out upon the face, having about the same proportions and degree of facial development as that of the opossum. It is perforated by a distinct lachrymal canal, which lies wholly within the rim of the orbit. The zygomatic arches are not preserved in either specimen, but, if we are able to judge by their roots, they may be said to have been intermediate in stoutness between those of the dog and of the opossum. The anterior part of the malar is preserved, and this, as is usually the case, furnishes the lower anterior boundary of the orbit. In the Carnassidentia, it joins the maxillary by means of a bifurcated extremity. In the fossil, the lower ramus of this bifurcation is very slightly developed—a condition which approximates that of the opossum, in which it is entirely wanting.

The frontals are rather broad anteriorly and terminate opposite the infraorbital foramen, in triangular extremities which do not meet the ascending processes of the premaxillæ. The position of the inconspicuous postorbital processes is indicated by the termination of the strongly-marked, rapidly diverging anterior branches of the sagittal crest, which furnish the posterior boundary of the frontal depression. The sagittal crest is not well preserved, but enough is shown to indicate that it had about the same relative degree of development as that of *Gymnura* and the Dasyures. The form of the brain case is much like that of certain of the civets, except that it is longer, narrower, and of less capacity; it is conical in front with a slight median swelling, after which follows a relatively long subcylindrical posterior portion. The parietals and

squamosals exhibit about the same relations as those of the dog, with the possible exception that the squamosal is larger. The parietal foramina, which in this region form such a conspicuous feature of the skulls of so many of the Creodonts, are very small; in fact, in the specimen under consideration, the one on the right side is practically absent.

The lambdoidal crest is only moderately developed, showing about the same degree of elevation as that seen in the living insectivorous genus *Gymnura*, which the superior and occipital portions of the skull resemble somewhat closely. The occiput is not very broad, and rises almost vertically to the plane of the long axis of the skull. It overhangs the condyles but very slightly, in marked contrast with its great backward projection in some of the Creodonts. The condyles are relatively very large, obliquely placed, and well separated. In comparison with those of a red fox, in which the size of the two skulls agrees very well, the occipital condyles of *Sinopa* are quite one-third larger. The extent to which the mastoid portion of the periotic is exposed upon the posterolateral wall of the cranium cannot be made out with certainty, but it appears to be very little, if any.

The base of the skull is in a state of excellent preservation, and its anatomy can be quite fully determined. The basioccipital is broad, and at the point of its articulation with the basisphenoid exhibits two prominent tubercles, separated by a longitudinal groove. The office of these eminences, which are roughened for muscular attachment, was doubtless for the origin of the *recti capiti*. The paroccipital is large, considerably flattened from above downward, and has a very marked outward and backward direction, as in the Insectivora. Just how much of this, however, is due to crushing, it is difficult to say, but it appears to be natural. The mastoid, which is separated from the paroccipital by a groove, is prominent, as in the Marsupials. The petrosal portion of the periotic is not covered by any tympanic bulla below, and if a tympanic bone were present it was not attached to the skull. There are, moreover, no expansions of the alisphenoid contributing to the formation of an otic bulla, as is so frequently the case in the skulls of the Marsupials and Insectivores. The petrosal portion of the periotic, when seen from below, appears as a small rounded eminence, near the outer posterior extremity of which, in a deep transverse groove, is seen the opening of the *fenestra rotunda*. In the Carnassident skull, this transverse groove is absent, and the opening of the fenestra is larger and somewhat tubular in appearance. Above, and anterior to this, is seen the opening of the *fenestra ovalis*, into which the base of the stapes is received. The absence of any groove leading

to the *fenestra ovalis* from below may be taken as conclusive evidence that the course of the entocarotid artery was essentially different from that in the modern Insectivora. Just external to the *fenestra rotunda* may be observed the peripheral termination of the fallopian aqueduct, through which the facial nerve made its exit from the skull. In front of the occipital condyle is placed the opening of the main condyloid foramen, and at some little distance in advance of it is the accessory or second condylar foramen—so constant a feature of the Marsupial skull, and occasionally found among living species of the Insectivora. Its office is apparently unknown. Immediately posterior to the petrosal eminence is situated the rather large elliptical opening of the foramen lacerum posterius, the size of which, in connection with the almost vestigial condition of the postglenoid foramen, would seem to indicate that the chief venous channel through which the cranial cavity was drained, made its exit at this point. A broad, but distinct, groove internal to this foramen leads forward to the fissure between the periotic and basioccipital, thence into the foramen lacerum medius situated in the angle at the junction of the periotic, basioccipital, and basisphenoid. That this was the point of entrance of the entocarotid artery is clear from its close resemblance to the corresponding parts in the skull of all of the Carnassidentia. In this important particular, it is therefore fundamentally different from the Insectivora and Marsupialia, and like the Carnassidentia. The foramen ovale is large and is placed as usual opposite to the glenoid cavity, at a considerable distance from the posterior edge of the alisphenoid. Just in advance of this foramen, and almost within the same aperture, is a small, but distinct, foramen leading into the *antrum* of the basisphenoid. In the opossum, this foramen is large and opens further in advance of the foramen ovale, but is connected with it by a distinct groove. Its office in this latter species is the transmission of a vein, a branch of which gains access to the cranial cavity through a small foramen in the floor of the pituitary fossa. There is no alisphenoid canal, but a slight groove marks the forward course of the ectocarotid at this point. The foramen rotundum and the sphenoidal fissure present separate openings, and are situated in a deep groove above the pterygoids. The opening of the rather large optic foramen is above, and considerably in advance of these two. Above and in advance of this, again, is the opening of the ethmoidal foramen for the passage of a branch of the nasal nerve.

The region of the glenoid cavity is considerably broken, but there is enough preserved to indicate that there was a strong postglenoid process, behind which is a small postglenoid

foramen. The pterygoids are well developed and the postnarial gutter is long and deep, much as in the dog and other typical Carnassidents. The posterior edge of the palatines is thickened and lies considerably behind the last molar. The palatal region is narrow in front and widens rapidly behind, being rather concave from side to side. The posterior palatine foramina have their usual position opposite the first molar, and behind them, in the palatines themselves, are numerous smaller accessory foramina. The incisive foramina are not well preserved, but there is evidence of their having had the usual slit-like openings.

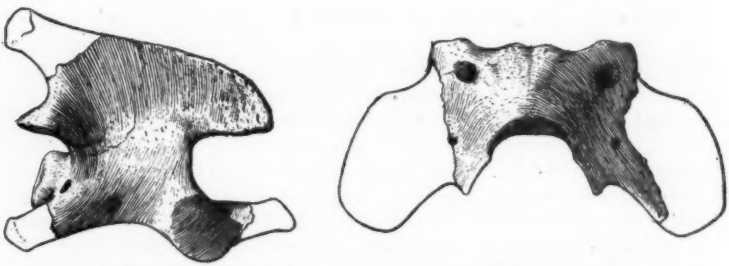
The lower jaw is long and slender, with a well-curved inferior border. The coronoid is wide and much elevated, the masseteric fossa well marked, and the angle produced into a long slightly inflected hook. The condyle is placed rather high and has the scroll-like pattern of many of the Carnivora.

The Dentition.—The teeth exhibit very marked progress toward the extreme sectorial structure of the later and more specialized members of the family. The dental formula is I. $\frac{3}{3}$ (?), C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{2}{3}$=44. Of the superior series, the outer incisors have much the same form as the corresponding teeth in the Carnassidents. The canines are long, pointed, and curved. The first premolar has a compressed, bluntly pointed crown, and is implanted by two roots about midway between the canine and second premolar, with a considerable interval or diastema in front and behind it. The second premolar has a more pointed principal cusp, which is inclined to be hook-shaped; there is in addition a small posterior basal talon. The third premolar is missing. The fourth has all the usual elements of the superior sectorial of the Carnassidents, but it is much less perfect as a shearing organ. The external parts of the crown include a low indistinct basal cusp in front, a slightly flattened conical principal cusp, and a posterior blade-like extension separated from the main cusp by a deep vertical fissure. There is a distinct lunate internal cusp. The first and second molars are subequal in size, the second being slightly larger than the first. The antero-external angle of the first is less distinct than that of the second, in which it is produced into a short, transverse, shearing blade. In other respects, the structure of the two teeth is the same. The two primary external cusps are connate for the greater part of their extent, only the points being separated. The posterior spur is enlarged, blade-like, and, in connection with the drawn-out posterior edge of the more or less fused externals, constitutes the chief shearing apparatus of the upper jaw. There is, in addition, a somewhat reduced internal lunate cusp, which, upon its anterior rim, supports a small intermediate. The last molar is transverse

and reduced; its antero-external angle is produced into a strong blade-like spur; the postero-external is wanting, and the internal is large.

In the lower jaw, the incisors and canines are unknown. The first premolar is small, single-rooted, and separated from the canine in front and second premolar behind by diastemata. The second premolar is two-rooted and also separated from the tooth in advance and the one behind by considerable intervals. The third and fourth are in contact. The first molar is the smallest of the three, and not only differs from its fellows in this respect, but the cusps of the trigon are less elevated. In all of them the trigon is well developed, the shear is little oblique, and the internal cusp is much reduced. The heels are relatively small, with a high single posterior cusp and a faint median ridge, that of the last molar being the largest.

85 86



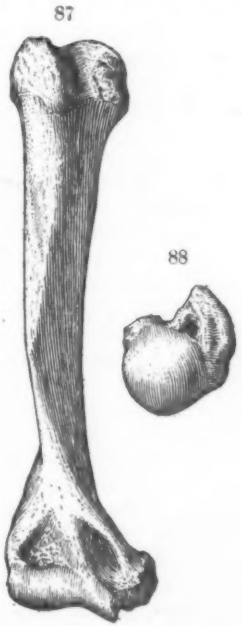
FIGURES 85, 86.—Atlas and axis of *Sinopa agilis* Marsh; natural size. (Cotype.)

While many other parts of the axial skeleton are preserved, they are not sufficiently perfect to merit a very detailed description. Of the series of cervical vertebræ, the atlas and axis, figures 85, 86, and the body of the third or fourth are present. The chief characters of these bones are the following: The transverse process of the atlas is relatively large, extends well behind the articular surfaces for the axis, and is thickened and perforated at the base for the passage of the vertebral artery; the further course of the artery forward is similar to that of the cat; the *sinus atlantis* is large, the cotyles deeply cup-shaped, the superior arch broad from before backward, and the inferior ring narrow and complete; the axis has a large, laminate, hatchet-shaped neural spine, which overhangs the odontoid in front; it is broken behind, but was presumably well extended; the odontoid is rather small and peg-like; the transverse spines are long, pointed, and pierced by the vertebrarterial canal; the ventral surface of the centrum has a very strong median keel, which increases rapidly in depth poste-

riorly, and on either side of this is a deep longitudinal cavity whose lateral boundary is furnished by the unusually dependent edge of the transverse process, much as in the fox; a third or fourth cervical centrum exhibits an elongated, depressed form, with strong median keel. The dorsals have elevated spines and comparatively small centra. The lumbars increase rapidly in size posteriorly; they have large strongly-interlocking zygapophyses, which exhibit distinct traces of the double tongue and groove articulation; they also develop distinct anapophyses.

The sacrum is relatively much longer and stouter than that of the fox, and its transverse diameter is proportionally quite as great, which latter fact would indicate a pelvic outlet of goodly proportions. This, in connection with the proportional size of the skull, is in marked contrast with the conditions in *Dromocyon* previously pointed out (p. 424). It may be here remarked that the same proportionally small pelvic outlet associated with the large head is also true of some species, at least, of *Hyænodon*. There are three cössified vertebræ in the sacrum, the two anterior only of which contribute to the formation of the auricular process for the attachment and support of the ilium—an essential and very constant feature of the Carnassidentia. Among the Marsupials generally, only one of the vertebræ, the anterior, furnishes this support, while in the living Insectivora, as many as three vertebræ are thus involved. The size of the sacrum is apparently in relation to the long and powerful tail, of which the numerous caudal vertebræ give ample evidence. These bones do not differ, as far as can be observed, from the caudals of other Creodonts.

Of the appendicular skeleton, many parts are preserved. The scapula, while represented by numerous pieces, is not sufficiently complete to furnish any information of its general form or outline. The glenoid cavity betrays some resemblances to that of the opossum, in the extent of the transverse diameter and the large size of the coracoid. In this latter feature,



FIGURES 87, 88.—Right humerus of *Sinopa agilis* Marsh; front and proximal end views; three-fourths natural size. (Cotype.)

it differs from *Hyænodon*, in which the coracoid is very short and vestigial. The humerus, figure 87, may be said to be intermediate in structure between that of the more generalized Carnassidents and the opossum. In its general outline, it bears a close resemblance to that of *Hyænodon* and differs markedly from any of the Insectivora. Its chief characters may be stated as follows: The head, figure 88, is not very pointed behind; the greater tuberosity is thick and rises to a level with the head; the lesser tuberosity is distinct and separated from the greater tuberosity by a moderately wide bicipital groove; the deltoid crest is long and powerful, extending down more than half the length of the shaft; the distal end is characteristically broad, with unusual development of the internal condyle and supinator ridge; there is a large entepicondylar foramen, imperforate anconeal and anticubital fossæ, and a distinct division of the articular surface into trochlea and capitellum.

The bones of the fore arm are not complete, both ulna and radius being represented only by their proximal and distal ends. The ulna, as in *Hyænodon*, is much less reduced, in comparison with the size of the radius, than that of the Carnassidents; it has a long, slightly incurved, and proximally grooved olecranon, a deep sigmoid cavity, and a moderately well-developed styloid process. The head of the radius is cup-shaped, subcircular, and capable of extensive pronation and supination, much more so, in fact, than that of *Hyænodon*, in which the ulnar contact is much flattened. The distal end is considerably expanded, of a trihedral form, and has a deeply impressed articular surface.

With the exception of the magnum, trapezoid, and centrale of the carpus, one phalanx, and a few inconsiderable fragments, the manus, figure 89, is complete. As compared with that of a specimen of *Hyænodon crucians* in the Marsh collection, the carpus agrees very closely in all the more important characters. The chief osteological features of the foot may be briefly stated as follows: The scaphoid, lunar, and centrale are free;* the lunar, upon its distal ulnar side, shows a considerable articular surface for the unciform, upon which it partially rests; internal to this is a larger facet by which it articulated with the head of the magnum; the pisiform, cuneiform, and unciform exhibit the usual form and relationship of the more generalized carnivorous type; the trapezium is large

* The superior articular surface of the scaphoid is not well represented in the accompanying drawing; it should be made to extend much further forward.

and supports a somewhat divergent pollex, which, however, is in no degree opposable; there are five metapodials arranged in the usual manner; they have but moderately developed interlocking articulations, and the toes are spreading; the third

89

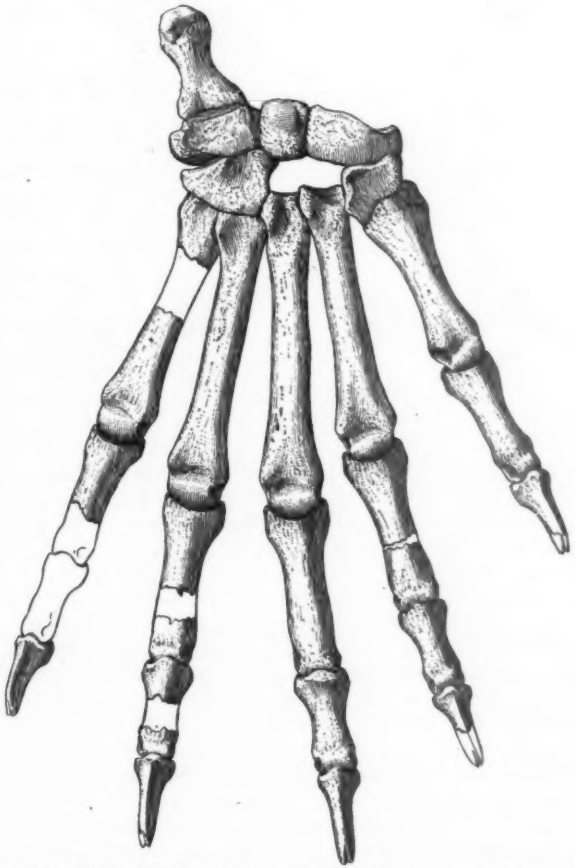


FIGURE 89.—Right fore foot of *Sinopa agilis* Marsh: three halves natural size. (Type.) The superior articular surface of the scaphoid is not well shown. As drawn, it appears to have great vertical depth in front, which is not the case.

metacarpal is the longest, and the second and fourth are about equal; the first is the stoutest and the fifth the smallest of the series; the phalanges are elongate and slender, and the bony

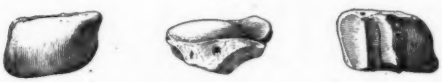
claws are compressed and pointed, figure 90, but at the same time slightly fissured at their extremities.

90

FIGURE 90.—Terminal phalanx of forefoot of *Sinopa agilis* Marsh; three halves natural size. (Type.)

Although the magnum, trapezoid, and centrale are missing, the distal articular facets of the lunar render it certain that the position of the centrale was entirely under the scaphoid, as in *Hyænodon*. In this connection, I wish to call attention to a specimen of *Hyænodon* in the present collection, which agrees very closely with *H. crucians* of Leidy. A portion of the carpus is preserved, and it is of much interest to note that the scaphoid, lunar, and centrale, figure 91, are coössified, with the remains of the sutures still visible. This carpus differs from the one figured by Scott,* in that the lunar has a large contact with the unciform, and the centrale lies wholly upon the radial side of the lunar, under the scaphoid.

91



a *b* *c*

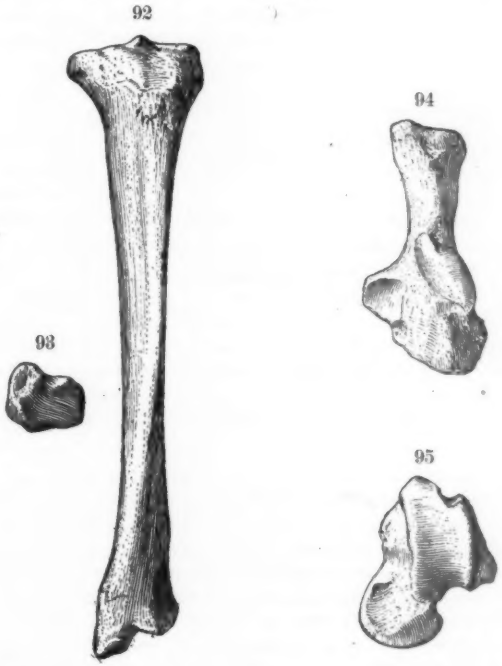
FIGURE 91.—Coössified scaphoid, lunar, and centrale, of *Hyænodon crucians* Leidy; natural size. *a*, top view; *b*, front view; *c*, inner view.

Of the pelvic girdle, the ilium is considerably expanded, and has a strong downward and outward curvature, as in *Hyænodon;* the peduncle is short and the tubercle for the *rectus* is large and rugose. The ischium is elongate and slightly expanded at its distal end. The pubis is not preserved.

The femur has a strong resemblance to that of *Hyænodon;* the hemispherical head is supported by a moderately short, stout neck; the *fovea* is distinct, the digital fossa deep, and the major trochanter rises almost to a level with the head; the trochanter minor is large, and the third trochanter is distinct and placed at a considerable distance down the shaft. The distal end of the bone exhibits the characteristic thickening of the lower end of the shaft, just before joining the condyles, as well as the general clumsy appearance seen in *Hyænodon*. The patella is relatively small, elongate, and narrow. The tibia, figures 92–93, is also markedly Hyænodont in character. The cnemial crest extends more than half-way down the shaft; the internal malleolus is large, and the trochlea is little grooved. The fibula is not so much reduced as it is in *Hyænodon*, but, as in that genus, there is a large contact with the calcaneum. The calcaneum, figure 94, has a moderately elongated tuber, and very convex astragalar and concave sustentacular facets.

* Jour. Acad. Nat. Sci., Phila., 1886.

The astragalus, figure 95, has a rather obliquely placed, vertically flattened, rounded head, a slightly grooved trochlea, and a vertical fibular facet. The astragalar foramen is distinct and



FIGURES 92, 93.—Left tibia of *Sinopa agilis* Marsh; front and end views; three-fourths natural size. (Cotype.)
FIGURE 94.—Left calcaneum of *Sinopa agilis* Marsh; dorsal view; one and one-eighth natural size. (Type.)
FIGURE 95.—Left astragalus of *Sinopa agilis* Marsh; dorsal view; one and one-eighth natural size. (Type.)

occupies its usual position. The remainder of the pes is unknown.

The principal measurements are given herewith:

Measurements of the Type.

Length of superior molar and premolar series, including canine	68·mm
Length of superior molar and fourth premolar	29·
Antero-posterior diameter of fourth superior premolar	9·
Antero-posterior diameter of first molar	9·
Antero-posterior diameter of second molar	8·

Antero-posterior diameter of third molar	3·mm
Transverse diameter of fourth premolar	5·5
Transverse diameter of first molar	7·
Transverse diameter of second molar	9·
Transverse diameter of third molar	8·
Length of inferior molar and premolar series, from posterior base of canine	66·
Length of inferior molars	24·
Antero-posterior diameter of first molar crown	7·5
Antero-posterior diameter of second molar (not type)	9·
Antero-posterior diameter of third molar (not type)	8·5
Length of manus	74·
Length of humerus	113·5
Length of third metacarpal	32·
Length of first phalanx, third digit	16·
Length of second phalanx, third digit	10·
Length of claw, third digit	9·
Length of sacrum	49·
Transverse diameter of sacrum	27·
Length of pelvis (estimated)	128·

Measurements of the Church Buttes Specimen.

Total length of cranium	149·mm
Length from incisive border to termination of palate	81·
Length from posterior border of palate to condyles	68·
Width of condyles	23·
Width of palate at and including second molars	40·5
Width of palate between canines	12·
Length from anterior border of orbit to condyle	94·
Length from anterior border of orbit to incisive border	58·5
Height of axis	27·
Length of humerus	115·5
Length of tibia	118·5

The type specimen was discovered by Professor Marsh, at Grizzly Buttes, and the cotype by R. Son, at Church Buttes, Bridger Basin, Wyoming.

[To be continued.]

Art. XXXVII.—*The Transmission of Sound through Solid Walls;* by F. L. Tufts, Ph.D.

In a previous article* the author gave the results of some experiments on the transmission of sound through materials pervious to air, and it was shown that such materials behave in the same way with respect to sound transmission and to the flow of air currents through them. In the present paper experiments are described which were undertaken for the purpose of studying the transmission of sound through materials impervious to air.

On account of the increased noisiness of cities and the desirability of excluding these noises from offices and dwellings, a knowledge of the laws governing the transmission of sound through various materials is becoming daily of greater importance, and the present investigation was, in fact, suggested by certain difficulties which had been encountered in excluding noises from telephone booths. The experiments, described below, were undertaken for the purpose of ascertaining the essential qualities which a wall must possess in order to render it impervious to the sound waves transmitted to it from the air.

Consider, for example, a sound wave traveling in air, and suppose it to impinge upon a solid wall; there are three conceivable ways in which the sound may be propagated through the wall to the air on the other side:

First, if the wall is pervious to air, the sound may be transmitted through the air in the pores of the material. The laws governing this kind of transmission were investigated in the previous paper.

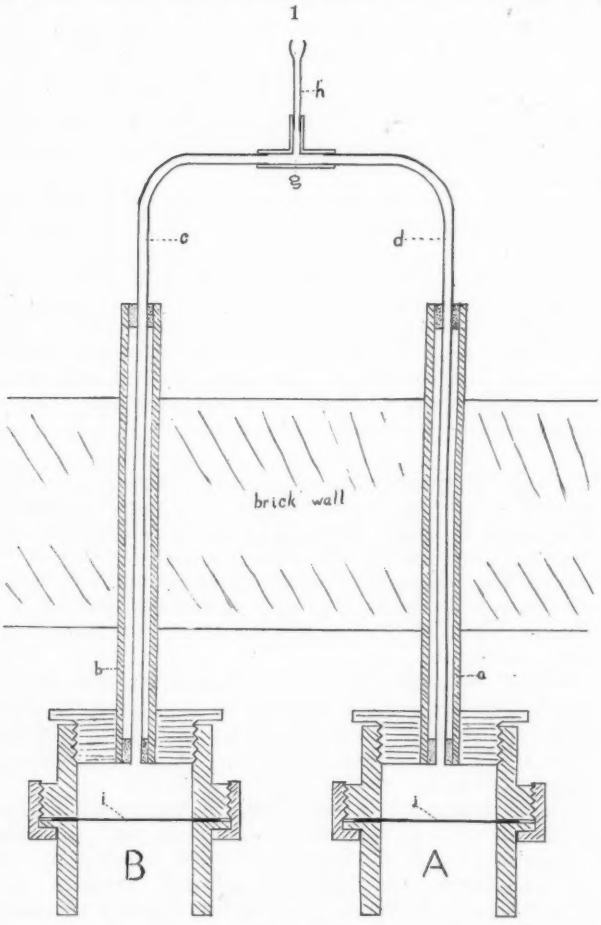
Second, if the material is impervious to air, the sound may be transmitted as an elastic wave in the material of the wall; or,

Third, the pressure of the sound wave against the wall may produce a slight displacement of it, and the sound may thus be transmitted as a vibration of the wall itself.

The apparatus used in studying the transmission of sound from the air on one side of an impervious wall, to the air on the opposite side, is shown in cross section in Fig. 1. A and B are two three-inch "gas unions," each fitted at one end with a "bushing" which reduces the opening to one inch. In these bushings, respectively, are screwed pieces of one inch gas pipe, *a* and *b*, about one foot in length. Rubber tubes, *c* and *d*, are passed through these pipes and are cemented in at their ends with beeswax. The rubber tubes are connected to

* This Journal, vol. xi, May, 1901, page 357.

a T-tube at *g*. One arm of the T-tube is provided with an ear piece, *h*, which can be inserted in the ear of the observer. The iron pipes, *a* and *b*, were inserted in openings in an eight-inch brick wall, and the observer could thus be placed in a



room adjoining the one in which the sound was produced. The materials, the transmission of sound through which was to be investigated, were cut into discs about 10·5^{cm} in diameter, and clamped in the unions at *i* and *j*, respectively. The application of a little cement rendered the junction air tight.

Various sources of sound were used in these experiments,

but that which proved the most satisfactory was obtained by dropping a metal ball upon a pine board, the height through which the ball dropped being adjusted until the sound was sufficiently intense to be heard through the discs under investigation. An observer in the adjoining room, with the ear-piece, *h*, in his ear, could, by alternately closing and opening the rubber tubes, *c* and *d*, easily ascertain which of the two discs transmitted the loudest sound.

The rigidities of the discs were measured in the following way; an upright index was cemented to the disc under investigation, and a microscope, provided with a micrometer ocular, was focused on a mark on the index. The disc was then subjected to a pressure of air through the tube, *c* or *d*, and the displacement of the index read off in the microscope. The excess of pressure of the air on the inner surface of the disc over the atmospheric pressure was measured by a suitable manometer. From the data thus obtained the displacement of the center of the disc, for a pressure of one gram per square centimeter of surface, was calculated. The value of this displacement is of course a measure of the rigidity of the disc. The following are some of the results obtained with the apparatus just described.

I. A lead disc $10{\cdot}5^{cm}$ in diameter and $\cdot012^{cm}$ thick, and a glass disc of the same dimensions, were clamped in the two unions respectively, and the intensities of the sounds transmitted through the two discs compared. It was found that the lead disc transmitted sound better than the glass one. The displacement of the center of the lead disc, for a pressure of one gram per square centimeter of surface, was $\cdot000106^{cm}$ and of the glass disc $\cdot000053^{cm}$.

II. A disc of white pine $\cdot65^{cm}$ thick was compared with a disc of leather of the same thickness. Both discs had been treated with paraffine to render them impervious to air. The displacement of the center of the pine disc was $\cdot000013^{cm}$ and of the leather disc $\cdot000212^{cm}$ for a pressure of one gram per square centimeter of surface. It was found that the leather disc transmitted sound very much better than the pine disc.

In both of the above cases the more rigid disc was found to be the poorer conductor of sound, although, in both cases it was composed of a material much better suited to the transmission of an elastic wave than the less rigid disc.

III. A brass disc $\cdot015^{cm}$ thick was braced by soldering to it a few cross strips of brass. This disc was compared with one formed of two thicknesses of cardboard treated with paraffine. The total thickness of the cardboard disc was $\cdot44^{cm}$. The displacements of the two discs for a pressure of one gram per square centimeter of surface were found to be the same,

viz: ·00008^{cm}. It was also found that they transmitted sound equally well, although the cardboard disc was nearly thirty times as thick as the brass disc.

IV. A disc was built up of ten sheets of cardboard treated with paraffine. The total thickness was ·70^{cm} and the displacement of the center for a pressure of one gram per square centimeter of surface was ·0002^{cm}. This disc was compared with a single disc of cardboard ·22^{cm} thick and which gave about the same displacement. It was found that the two discs transmitted sound equally well, although one consisted of many layers while the other was of a single homogeneous material.

V. The braced brass disc used in experiment III, above, was compared with a disc cut from the same piece of brass, and which had a small mass of brass soldered to its center. The total mass of the two discs was thus made the same. The displacement of the center of the loaded brass disc, for a pressure of one gram per square centimeter of surface, was ·0022^{cm} while that of the braced disc was ·00008^{cm}. The loaded disc transmitted sound very much better than the braced disc. Even the noises from the street which entered the room could be easily heard through the loaded disc, while nothing of this kind could be heard through the braced disc.

An examination of the above cases, I to IV inclusive, makes it evident that the amount of sound transmitted through the discs as an elastic wave in the material, must be negligibly small as compared to that transmitted as a to and fro vibration of the disc itself; were this not so, then in case IV, where the two discs possess the same rigidity, one would expect the sound heard through the single homogeneous disc to be louder than that heard through the built-up disc with its many reflecting surfaces. In other experiments, where comparatively rigid discs of materials well suited to the transmission of elastic waves, were compared with less rigid discs composed of materials not so well suited to the transmission of such waves, it was found in every case that the less rigid disc transmitted sound better than the more rigid one in spite of its unfavorable composition. The experiments, therefore, show that when sound is transmitted from the air on one side of the disc, through the disc, to the air on the opposite side, the transmission takes place almost entirely as a to and fro vibration of the disc.

The experiment described under V shows that the effect of mass in a wall is of minor importance as compared to rigidity. The lead disc, in I, had nearly six times the mass of the glass disc, but even this great increase in mass was more than compensated for by the fact that the lead disc gave a displace-

ment twice as great as the displacement of the glass disc for the same pressure.

In order to investigate the effect of the mass of a wall on its conductivity for sound, two cardboard discs of the same dimensions were used. Both were treated with paraffine, and when clamped in the unions, both gave displacements of ·0004^{cm} for a pressure of one gram per square centimeter of surface. The intensity of the sound heard through the two discs was, as far as could be judged, the same. The discs were ·22^{cm} thick, and each weighed 17 grams. To the center of one of the discs was now cemented a mass of lead weighing 34 grams, and it was found that this cut down the intensity of the sound transmitted through the disc by a very appreciable amount. The effect due to the addition of a mass of five grams could be readily detected if the mass was cemented to the disc at its center, but not when the mass was cemented about half way between the center and circumference. This experiment shows that, other things being equal, the wall possessing the greatest mass will be the poorest conductor for sound. When the mass is uniformly distributed through the disc, however, a very slight increase in rigidity will more than compensate for a very considerable decrease in mass. For example, a lead disc, weighing 145 grams, was compared with a disc of red cedar, weighing only 17 grams, the lead disc gave a displacement of ·00008^{cm} and the red cedar disc a displacement of ·00005^{cm} for a pressure of one gram per square centimeter. It was found that the lead disc transmitted very perceptibly better than the red cedar disc, although it contained over nine times the mass.

It is a common practice in the construction of telephone booths to make them of two, and sometimes of four walls, separated by air spaces, and there seems to be an opinion that such a form of construction is better adapted for the exclusion of sound than one in which the same amount of material is put into a single wall. In order to test the relative merits of the two types of construction, six discs were cut out of cardboard and treated with paraffine in order to render them impervious to air. In one of the unions three of the discs were placed, and separated by cardboard washers, so that an air space of two millimeters was left between the discs. In the other union three discs were clamped in contact. It was found that the discs separated by air spaces transmitted sound better than the discs which were placed in contact. The same experiment was repeated using brass discs and with a similar result. The increased rigidity obtained by placing the discs in contact more than balanced any advantage there might be in having the intervening air spaces.

In all of the experiments above described the source of sound, as has been stated, was a single pulse obtained by dropping a metal ball on a pine board. Some of the experiments were repeated using an organ pipe as the source of sound. In this case it was found that the results might be much influenced by the pitch of the note used. If the natural period of vibration of a disc was in unison with the source of sound, while that of another less rigid disc was not, the transmission might be greater through the more rigid disc.

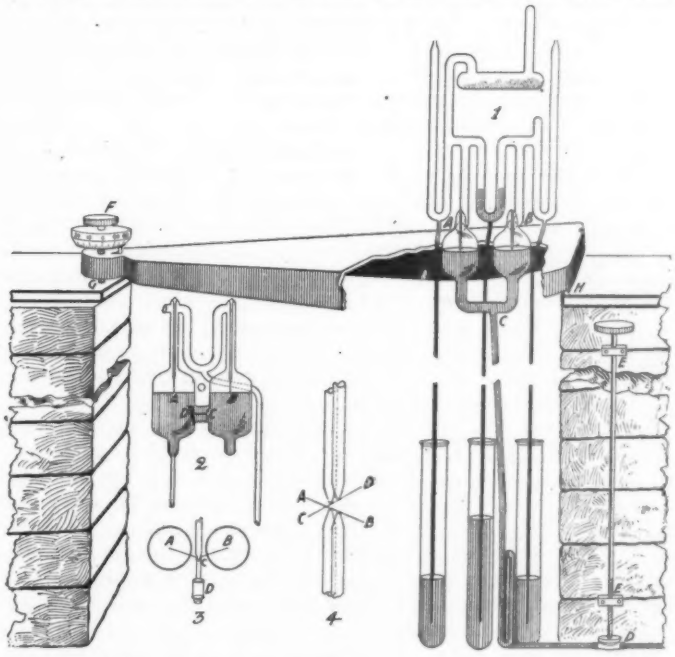
In conclusion, it may be stated that the experiments described above are representative of many others of a similar character. In every case the rigidity of the disc was found to be the main factor in determining the intensity of the sound transmitted from the air on one side of the disc to the air on the opposite side. The only other factor which seemed to have an appreciable influence on the transmission of sound through the disc was its mass. It was found that of two discs having the same rigidity the one possessing the greatest mass was the poorest conductor of sound. The effect of increasing the mass of a disc is, however, many times smaller than the effect of increasing its rigidity.

The above experiments show that the commonly accepted analogy between the transmission of sound and that of light does not hold where the sound is transmitted from the air on one side of a solid medium, through the medium, to the air on the other side. In such cases it has been found that an entirely different principle is involved, and that the transmission takes place as a to and fro vibration of the wall itself, and not as an elastic wave traveling through it.

Physical Laboratory of Columbia University,
New York City.

ART. XXXVIII.—*A new Gauge for the Measurement of Small Pressures;* by EDWARD W. MORLEY and CHARLES F. BRUSH.

IN 1888 and again in 1889, one of us constructed two gauges of a new form, intended for the direct measurement of small pressures. About three years ago, a third instrument of the same kind was used by us for the measurement of the pressure of the vapor of water; the time required for a measurement was rather long, and we accordingly constructed two more instruments of a somewhat different form, in which



the time needed for a reading is no more than that required by a filar micrometer. We shall now describe both forms; not only the somewhat costly apparatus which economizes time when many measurements are to be made, but also the simple and less expensive form which may well serve where but few measurements are required.

In figure 1, *a b* is a siphon gauge, consisting of tubes about five centimeters in diameter, connected below by a smaller

tube. Within these tubes are fixed two platinum points, on the same level. The points must be rather accurately shaped. To this U-shaped gauge is connected the tube *c*, and a thick-walled rubber tube *d*, which can be compressed by the screw *e e*; *d* is continued by a glass tube used to adjust the level of the mercury in *a b* when the apparatus is set up, and then closed by fusion. By means of the screw and the rubber tube, the level of the mercury in *a b* can be adjusted with any needed degree of accuracy.

This gauge is firmly cemented into a metal girder or beam. This beam rests on two points at *m*, and on the point of a micrometer screw at *n*.

The instrument has to be mounted on a stable support. Ours is placed on a brick pier having a recess for the tube *c*. On the tops of the two projecting parts are cemented two glass plates; on one of them rest the two points *m* and on the other the point of the micrometer screw *k*. Guard rings keep the points in the assigned position.

The method of using the apparatus is simple. We must first determine the reading of the micrometer when the pressure in *a* and *b* has been made the same by putting them in free communication by the mercurial valve shown. We turn *k* till the depressions made by the two points in *a* and *b* seem equal. Then we lessen the compression of *d* and so lower the level of the mercury in *a b* till one of the depressions is barely perceptible. These two steps are repeated; we equalize and then reduce the depressions till they are equal when made the *minimum visibile*. The reading of *k* is then the reading for equality of pressure in *a* and *b*.

The method of comparing the depressions requires no optical assistance. The observer places himself so as to see the image of a horizontal window-bar reflected by the two mercury surfaces. Moving his eye so as to cause the image to pass across the depressions, their dimensions are easily compared. As they are made smaller by lowering the level of the mercury, the error of comparison becomes smaller. When they are barely visible, this error may easily be made less than 0·00002 cm.; after some practice, of course.

When we wish to measure the difference of pressures in *a* and *b*, we make a new reading in the same way. The difference between the readings, taken with the length *m n*, and the value of a turn of the screw, will define the inclination which has been given to the apparatus in order to make the two points again tangent to the two surfaces of mercury. The linear distance between the points is determined when the apparatus is constructed; in our instrument, this was done by measuring with a cathetometer while the tubes *a b* were

still open at the bottom. Knowing the inclination and the distance *a b*, we know the difference of level between the two points, and therefore the difference of pressures. One arm of the gauge *a b* is permanently connected with a McLeod gauge and a mercurial pump, and care is taken that this side shall be filled with a gas for which the McLeod gauge may be trusted.

With this apparatus, a measurement can scarcely be made in less than three minutes; even after much practice. We have accordingly constructed two instruments in which we still utilize the principle of measuring the tilting of the apparatus needed to bring mercury levels to the fiducial points, but in which Mr. B. has applied a very different method of reading. At *a b*, figure 2, are the two arms of the gauge, seen in horizontal section through the fiducial points. At *c* is a pair of mirrors so placed that, in a microscope at *d*, the two points *a b* are seen side by side. These two mirrors are wrought on the end of a glass rod some six millimeters in diameter. They are mounted on a spherical base, so that they can be rotated in any desired way about a point in their intersection. They can also be moved in the direction *c d*.

The two arms of the gauge, the mirrors, and the microscope, are all rigidly fixed to a support whose inclination is determined by a micrometer screw. Since the points, mirrors, and microscope are all moved together, vision of the points always takes place under precisely the same conditions.

The amount of mercury in the gauge is capable of adjustment, somewhat as in the first form, but the adjustment does not require to be so delicate.

When, with suitable illumination, we look in the microscope, we can not see the surface of the mercury, but we see two images of each point. One image of each point is seen directly, and one image is seen by reflection from the surface of mercury. It is important that the ends of the points shall be small hemispheres. Suitable adjustment causes the four images to appear as in figure 4. When a difference of pressure is to be read, the micrometer screw tilts the whole apparatus, and the two tangent lines *a b* and *c d* are quickly made parallel, when the reading is taken. Ten seconds may well suffice, especially if the eye is assisted by an eyepiece micrometer with parallel lines. It will of course be noticed that the reflection from the surface doubles the distance to be measured.

In the instruments which we have used, which were intended only for the measurement of small pressures, we made our U-tube less than an inch long. To do this with tubes six centimeters in diameter required us to connect the two vertical arms by a horizontal cross-piece, so that our apparatus looks more like the letter H than U. To secure

uniformity of temperature, we made this connecting tube two centimeters in diameter. With such freedom of communication, anywhere in a city, there is a continual slight oscillation of the mercury between the two arms of the gauge. Accordingly, in the second apparatus constructed, we damped the oscillation by putting a thin metallic diaphragm in the connecting tube. This may consist of a platinum cone tied in place with a wire and a wedge of glass, as suggested by figure 3.

An important matter in the construction of such a gauge needs mention. It is but through a small part of the surface of a glass tube that good definition of the points can be had with the microscope. One must select a number of such places in his stock of glass tubes, and mark the best of such favorable places. In the completed apparatus, the selected areas are brought to the predetermined position.

The mounting of the apparatus has to be about as stable as that of an astronomical instrument. It must be so designed that distortion shall not be caused by changes of temperature. In our gauges, a massive cast-iron standard rests on a isolated stone pier. On this, moving in trunnions like those of a transit instrument, is carried the plate to which gauge, mirrors, and microscope are fixed. With such stability, and with many precautions, we have been able to measure small pressures with a mean error not much greater than the ten-thousandth part of a millimeter.

It may be noted that in the first form of gauge it is best to use points of platinum, for glass points can not well be given the form permitting most convenient manipulation, that of a right cone of small angle. The adhesion of mercury and glass also causes much loss of time. In the second form, where the points must end in minute hemispheres, and where actual contact of mercury and the point is not required, glass points can be used, but the ease with which platinum points can be given a proper outline in the lathe speaks in their favor.

NOTE—Since this paper was written, we have learned that Lord Rayleigh has used with success a gauge much resembling the first form used by us; he determined the inclination given the gauge in making the points tangent to the mercury, by observing with a reading telescope the inclination given to a mirror carried with the gauge.

Adelbert College, Cleveland, Ohio.

ART. XXXIX.—*On a Hitherto Untried Form of Mounting, either Equatorial or Altazimuth, for a Telescope of exceptional size, either refractor or reflector, in which Telescope, observing-floor and dome are combined in one;* by DAVID P. TODD, Director Amherst College Observatory.

NEARLY all the great telescopes of the world have in turn signalized their extraordinary power by an important astronomical discovery. Sir William Herschel's reflector first brought to light the planet Uranus; Lord Rosse's Leviathan, the spiral nebulæ; the 15-inch Cambridge telescope, Saturn's dusky ring; the 18-inch Chicago refractor, the companion of Sirius; the Washington 26-inch, the satellites of Mars; the 30-inch Pulkowa objective, the nebulosities of the Pleiades; and the 36-inch Lick telescope revealed a new satellite of Jupiter.

With such a record is it not safe to predict farther advance with larger telescopes still? There is as yet no indication that a refracting telescope of five or even six feet aperture would fall short of a gratifying success to its projector. Two American opticians, of wide experience and high competency, can be relied upon to grind and figure such an object glass. To be most effective, it must be as thin as possible—which means that its focal length must be very great. Therefore the question of a suitable mounting becomes all important.

The difficulties inherent to the conventional type of mounting practically prohibit any great increase of size, because the tube is hung at or near the middle. This is in many respects the least advantageous point. The tube should be rigidly supported at or near both ends, as well as in the middle. If, then, we invoke the fertile resources of the modern bridge engineer, and his relatively light but rigid constructions of steel, the fixedness of axis in all positions of the great telescope becomes a requisite easily met.

The object of this paper is to outline one method of applying modern engineering resources to the mounting of a telescope of exceptional proportions.

A sphere 100 feet in diameter can readily be designed and built, with an interior, meridional rib-structure so rigid that flexure deformation will not exceed a small fraction of an inch. We coat this sphere, first with steel plates, then with oak planks about three inches thick. These not only allow the exact spherical figure to be trued up, but also, like the wooden sheathing sometimes employed on men-of-war, permit attachment of an outer coating of copper,—or better still, of Tobin bronze.

We float this sphere, in such manner as to admit the utmost ease of motion in any required direction. Masonry of brick or stone is built, about 25 feet in depth, and perhaps 100 to 120 feet square. This is constructed in the shape of a zonal basin with Portland cement, and its interior is smoothed up to exact figure, by erecting a platform above the center of the basin, and swinging from it a convex trowel attached to a radial arm.

The sphere is of course assembled and erected piecemeal *in situ*. A small amount of wood-preserving liquid is added to the basin, as the sphere is built up; and this suffices to keep it always just floated, thus making it very easy to turn into any desired position for attaching one part after another. When the steel coating of the sphere is finished, the wooden jacket is next put on, the structure all the while floating in preservative, till this exterior of oak is complete and trued up to figure. Then the bright metal sheathing begins. When finished, the preservative is withdrawn, and water substituted therefor. Only a few barrels of water poured into the basin will be required to float the sphere and all its subsequent appurtenances. The water is made part of a circulatory system, and warmed in winter to prevent freezing.

If we are content with a telescope a little short of 100 feet in focal length, the object glass may be set in the surface of the sphere. On its opposite side, the eyepieces, spectroscopes, photographic cameras, and other accessories are capable of permanent and rigid attachment to its internal rib-work.

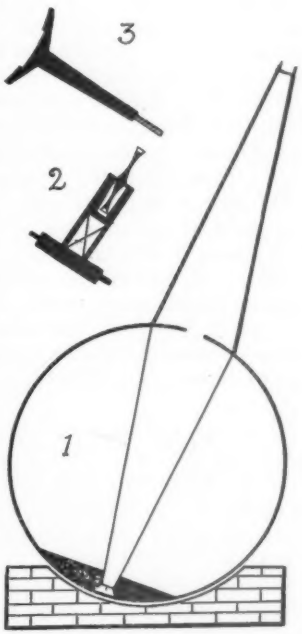
The observer is there, too; but free to move about on a swinging platform, a good model of which is furnished by the glass crystal of an ordinary ship's chronometer. The platform maintains itself always horizontal, no matter in what direction the axis of the telescope is pointed.

But a sphere of 100 feet diameter very readily admits the possibility of a telescope approaching 200 feet in length, if we attach a tube 100 feet long to the exterior of the sphere. This method of mounting the objective is illustrated schematically in the engraving (fig. 1).

At intervals of perhaps 30 feet, girdling rings are attached to this exterior tube, and to these are fastened guy-rods which anchor in the outside of the sphere, thereby holding the outer end of the tube rigidly in position, even if the weight of the objective in its cell should be as much as a ton.*

*The author is not unaware of certain objections to the design proposed, and others may be suggested. The effect of temperature inequality is one. An obvious objection arises from the vibration which it is natural to suppose a variable wind pressure would induce. But the open-air telescopes of Sir William Herschel, Lord Rosse, and Lassell were subject to this difficulty also. Experiment with a model of perhaps one-quarter or one-third the full size seems to the author the best method of testing the validity of these objections.

Tube, objective, and guy-rods are all counterpoised by means of permanent weights on the interior of the sphere, adjacent to the self-adjusting observer's platform (not shown). An objective weighing a ton is counterpoised by a mass of three tons. The mirror for a great reflecting telescope might form the counterpoise.



When not in use the sphere is revolved until the exterior tube comes down to a nearly horizontal position, and the objective is weather-proofed underneath a removable roof (not shown), something like that of a transit-room. The objective is then accessible in all weathers, for adjustment or other requisite service. With the tube in this position, the observer and his assistant enter the sphere through a door in the tube close to its juncture with the sphere itself. They walk along an internal *trottoir*, till they reach the adjustable platform. This is maintained always charged with its maximum load; if additional observers go in, their equivalent weight is removed from the platform, and deposited outside the sphere before observations begin. In this way, the sphere is kept submerged to a constant depth—a requisite, the design of which will be apparent farther on. From this platform and out through the opening extends an electrical cable, with perhaps twenty independent circuits, each of which controls an exterior automatic apparatus, whose action very readily gives to the sphere any rapid motion that may be desired, as follows:

(1) In altitude.
(2) In azimuth.
(3) In declination.
(4) In right ascension.

These motions suffice for any necessary pointing of the telescope. I need not here go into the details of these automatic mechanisms further than to say, that the specified motions may be obtained by means of rubber-faced wheels, strongly mounted in swinging forks or levers (fig. 2), and

engaging the outer surface of the sphere. Three wheels for each coördinate, mounted in proper planes, all press against the outside of the sphere simultaneously, and electric motors then turn them at the speed required. The sphere can, of course, be revolved in but one coördinate at a time; and the cable connection enables the observer inside the platform to throw into gear any treble set of wheels he may desire.

Above the platform, or alongside it, are the automatic setting devices, one for the horizon system, and another for the equinoctial system of coördinates. At the zenith of each of these is an index, which shows, as a vernier on graduated circles, the pointing of the tube. These setting-systems are gimbal-mounted and pendulum-controlled, the antique armillary sphere furnishing the basis of their design.

A peculiar sort of finder is essential—with a duplex coudé tube, so that its eyepiece can be brought close to the eyepiece of the great tube.

Slight differences of poise in the sphere and its appurtenances are compensated through the instrumentality of radial rods, upon which travel masses of a few hundred weight, by means of rack-and-pinion motors. Thus the sphere's center of gravity is easily adjusted to exact coincidence with its center of figure.

Probably the moving sphere and all its accessories will weigh not far from 2000 tons, and it must be as susceptible of delicate adjustment and subsequent following-motion as is a telescope of the usual German or English type of mounting. Quite obviously such a great telescope will require clockwork of exceptional power.

Two or three methods of clock-motion are feasible: I will outline but one. A huge polar axis (fig. 3) is built into the exterior masonry due south of the sphere, and its upper end terminates in four arms, each of which carries a large shallow cup, of the exact spherical concave. These cups are faced on the inside with rubber belting; and when the chuck is in action—(telescope clamped in right ascension)—they push with a few hundred pounds stress against the sphere. Two rubber-faced wheels, on the northwest and northeast sides of the sphere, oppose the poleward thrust of the chuck. They are of course mounted parallel to the equatorial plane. We depend upon the polar axis and opposing wheels to preserve the axis of rotation of the sphere invariable. This axis passes in a constant direction through the center of figure of the sphere. We apply the clock power, not to the polar axis itself, but to an opposing pair of rubber-faced wheels, whose planes are coincident with the sphere's equator. There is thus the distinct advantage of a driving wheel 100 feet in diameter.

An electric motor, or gas engine electrically controlled, will be found well adapted to this delicate service; but in order that the movement may be perfectly steady, care must be taken to provide a considerable excess of the power actually necessary to set the sphere in motion.

I have given much attention to the question of slow motions. Several different schemes are possible, and all admit of automatic control and action through the multiplex cable. Should it be desired to maintain the utmost delicacy of adjustment in the field, for spectroscopic or micrometric work or long-exposure photography, it may be found best to provide a sliding collimator-plate, to which the tail-piece is rigidly attached. Corresponding and appropriate collimation of the objective would not offer any serious mechanical difficulties.

No one familiar with observatory construction will fail to notice that this projected type of instrument combines telescope, observing-chair and dome all in one. I have made an attempt to estimate the cost of such an astronomical establishment, but the largest present element of uncertainty pertains to the sphere itself.

As the sphere will not need the ordinary running-gear, we cannot be far wrong in estimating double the cost of a hemispherical dome. This will make,

Approximately	$175,000
Allow for a 5-foot objective	75,000
For the masonry and cement basin	5,000
For the clock-work and motions	10,000
For the tube and eyepiece accessories	10,000
	$275,000

I need hardly add that some of the unique advantages of M. Loewy's equatorial coudé are available with this type of mounting; for by sealing the internal tube, the sphere or a part of it can be kept at a comfortable temperature by electric heaters. And if such a telescope were installed on a high mountain, the barometric pressure of sea-level might be mechanically maintained within a compartment of the sphere, housing over the adjustable platform. By connecting with exterior rooms through closed passage-ways, this might readily be so contrived as to safeguard the observer against those serious effects of *mal des montagnes*, which hitherto have precluded the permanent astronomical occupation of mountain elevations much in excess of 8,000 feet.

Amherst, Mass.

Art. XL—*On the Occurrence of Uranophane in Georgia;* by Thomas L. Watson.

[Published by permission of W. S. Yeates, State Geologist of Georgia.]

The object of this paper is to describe the occurrence of the rare mineral uranophane from a new locality. State Geologist Yeates first observed the occurrence of the yellow mineral at Stone Mountain, Georgia, in the early nineties, and later had Mr. R. L. Packard examine the material chemically in the laboratory of the Georgia Survey. During 1898 and 1899, while engaged in a field study of the Georgia granites, the writer independently noted the occurrence of this mineral at the same locality, as a thin, yellow incrustation coating the faces of many of the joint planes cutting the Stone Mountain granite mass. Specimens were carefully collected and studied in the laboratory of the Survey in Atlanta.

So far as the writer can ascertain, uranophane is reported from only one locality in the United States, namely, Mitchell County, North Carolina.* Here the mineral is found incrusting and penetrating gummite as an alteration product at the mica mines. Under the title "On Some New Mineral Occurrences in Canada," G. Chr. Hoffman† of the Canadian Geological Survey has recently described the occurrence of uranophane from Ottawa County, Quebec. According to Hoffman, the mineral in Quebec is associated with "gummite, uraninite, black tourmaline, white, light gray, pale olive-green and bluish green apatite, spessartite, monazite, and green and purple fluorite, in a coarse pegmatite vein composed of white and light to dark, smoky-brown quartz, microcline and muscovite, which traverses a gray garnetiferous gneiss." The mineral is further described as an alteration product of gummite, occurring "in small bright lemon-yellow fibrous masses, sometimes in immediate contact with the gummite found coating the uraninite or, *per se*, embedded in the albite immediately surrounding the tourmaline and often invading the latter." In both Quebec and North Carolina the mineral is an alteration product of gummite, and, in this particular, its occurrence is similar for the two localities, while in Georgia the occurrence is entirely different, as will be noted in the following description.

At Stone Mountain, Georgia, sixteen miles east of Atlanta, the mineral uranophane is found as a distinct incrustation, coating the faces of many of the joint planes, which cut the granite boss. It varies from a sulphur-yellow to lemon-yellow in

* Dana, E. S., A System of Mineralogy, 1893, p. 699.
† This Journal, vol. xi, pp. 152–153, 1901.

color, the former predominating, and forms an irregular coating not exceeding one-eighth to one-sixteenth of an inch in thickness, usually less. It is tipped or coated with the clear, colorless, and transparent, drop-like forms of the mineral hyalite. The two minerals are so intimately associated that it is almost impossible to effect a complete separation of them.

The Stone Mountain granite, with which the uranophane is associated, is a light gray, medium-grained, biotite-bearing muscovite granite, composed of quartz, orthoclase, microcline and soda-lime (oligoclase) feldspar, muscovite and biotite, with sporadic microscopic accessories. Fresh specimens of the granite were analyzed by Packard in the Survey laboratory with the following results:

SiO_2	72·56
Al_2O_3	14·81
FeO	0·84
CaO	1·19
MgO	0·20
Na_2O	4·94
K_2O	5·30
H_2O (ignition)	0·70
Total	100·54

Several tests were made by the writer on separate portions of the granite for the presence of uranium, with negative results. The yellow powder gave the usual tests before the blowpipe for uranophane. Packard carefully separated, by means of a lens, a small amount of the yellow mineral from particles of the granite and other possible impurities for chemical analysis. 0·1310 gram of the powder was used, which gave:

SiO_2	18·55
$U(UO_4)_2$	47·18
$(UO_2)_3$, Fe_2O_3, P_2O_5	4·95
Al_2O_3	6·33
CaO	6·64
MgO	1·98
H_2O (ignition)	13·28
Total	98·91

As Packard remarks, the above result clearly indicates that the material was not entirely free from impurities. A second weighed portion was accordingly selected amounting to 0·5120 gram of the dull lemon- or sulphur-yellow mineral and treated with HNO_3, which after digestion left a residue weighing 0·2460 gram, yielding 0·2660 gram for analysis. This gave:

$U(UO_4)_2$ 61·28, corresponding to 60·14 per cent of UO_3; CaO 6·01.

Accepting then the percentages of SiO_2 and H_2O in the first analysis, and those of UO_3 and CaO in the last, as representing the composition of the mineral; and disregarding the percentages of Fe_2O_3, Al_2O_3, MgO and P_2O_5, and recalculating the four essential oxides to a basis of 100, the ratios become:

	I.	II.	III.	
CaO	6·01	6·14	·109	= 1
UO_3	60·14	61·37	·213	= 1·95
SiO_2	18·55	18·93	·315	= 2·88
H_2O	13·28	13·56	·753	= 6·90
	97·98	100		

I. Analysis of uranophane from Stone Mountain, Georgia, from which the small percentages of Al_2O_3, Fe_2O_3, MgO and P_2O_5 are omitted.
II. Analysis I recalculated to a basis of 100.
III. Molecular ratios of II.

The molecular proportions given under column III correspond to the formula $CaO{\cdot}2UO_3{\cdot}3SiO_2+7H_2O$, which indicates one part more of SiO_2 and H_2O than is required by the formula for uranophane, $CaO{\cdot}2UO_3{\cdot}2SiO_2+6H_2O$. The discrepancy in these two constituents is easily accounted for, however. The SiO_2 is increased by the presence of finely divided mineral particles from the granite and hyalite, it being quite impossible to effect a complete separation of the uranophane from these two. The amount of available material was so small that it was impossible to separately determine the combined and uncombined water, and under the total water given in the analysis, it is reasonable, at least, to assume that a small fraction of it is hygroscopic (uncombined) water. What now appears then as a slight variation from the exact formula for uranophane, disappears when the above facts are considered.

A comparison of the above analysis of the Georgia mineral with several by Genth and von Foullon of the uranophane from Mitchell County, North Carolina, and one from Kupferberg, Silesia, quoted by Dana,* shows very close agreement. The reported occurrence of uranophane in granite at Kupferberg in Silesia appears in this particular to be similar to that in Georgia.

Geological Laboratory of Denison University,
Granville, Ohio.

*Op. cit.

ART. XLI. — *Internal Structure of Cliftonite;** by JOHN M. DAVISON.

GRAPHITE crystallized in the isometric system was first found by Haidinger in the Arva meteoric iron; afterwards by Fletcher in the Youndegin and Cocke Co. irons and was named by him cliftonite. Huntington afterwards found it in the Smithville iron.

Fletcher thought these crystals were pseudomorphs after pyrite. Rose and Brezina hold that they have been altered from diamond to graphite.

In dissolving a troilite nodule from the Smithville iron the writer found a number of these crystals. Some were loose in the residue from the aqua-regia solution, and all of these were cubo-octahedral in form, the planes of each being equally developed. The crystals were from 0·13^{mm} to 0·23^{mm} in diameter. Other crystals of about the same size were attached to larger pieces of uncrystallized graphite, seemingly in form of a curving string of compressed cubes or plates. On two of these plates angles of 120° and 104° could be roughly measured. Other angles seemed to be 90°.

To see whether the cliftonite crystals occurred also in the kamacite and tænite a piece of the Smithville iron of about the size of the troilite nodule was dissolved. In the insoluble residue fragments of graphite and a single hexagonal plate of graphite were found but not one of the cliftonite crystals.

Four of the cubo-octahedrons were mounted in Canada balsam and carefully ground with a fine hone. The grinding was parallel to a face of the cube. On each, as the cube face enlarged, a square appeared lying within, its sides parallel to the planes of the octahedron and turned 45° from the edges of the cube. As the grinding went on this square enlarged to a maximum and then decreased, thus showing that the embedded form was not a cube but an octahedron which was being ground normal to a solid angle.

Measurements on two of the crystals gave these successive sizes of the squares:

Cliftonite crystal		0·23^{mm} × 0·24^{mm}	Cliftonite crystal		0·15^{mm}
inner square		0·04	inner square		0·07
"	"	0·08	"	"	0·06
"	"	0·10	"	"	0·05
"	"	0·06	"	"	0·04
"	"	0·03			

* Read before the Rochester Academy of Science, April 14, 1902.

In the case of the smaller crystal the grinding had reached or passed the center of the internal octahedron before the first measurement was made. In neither case was the grinding pushed to disappearance of the internal form.

This internal structure confirms the view that cliftonite is not a pseudomorph after pyrite, for it would be impossible to reproduce the internal structure of pyrite under the conditions of the case. But it is not so clear that diamond has here been changed to graphite rather than that graphite has crystallized in a form differing from telluric graphite because of differing conditions.

Carbon crystallizing from molten iron under atmospheric pressure takes the graphite condition with hexagonal form. And, as Moissan has shown, it may, in some cases, under greater pressure take the diamond condition with isometric form. Why may it not under somewhat different circumstances take the graphite condition with isometric form having a hardness greater than hexagonal graphite, as Brezina found cliftonite to have?

The curving string of plates was likewise examined for internal structure, but none was found.

With the cliftonite crystals were a few transparent particles, some of which withstood fusion with sodium carbonate and four evaporations with hydrofluoric acid and presumably were diamond fragments.

Rochester, N. Y.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Heatless Condition of Matter.* — Brinkworth and Martin, with apparent seriousness, have made a curious extension of the kinetic theory. Assuming that heat is due to molecular motion, they suppose a solid to be placed in an infinitely strong and unyielding cylinder, made of a heat-conducting substance, and slowly compressed. As the compression proceeds the molecules are driven closer together, heat is evolved, but this is conducted away. Ultimately the molecules will be driven into absolute contact and will be so tightly pressed, the one against the other, as to be absolutely unable to move relatively to each other. Therefore, in this condition the molecules can possess no kinetic energy or relative motion of any description; but, according to the kinetic theory, the temperature of a body is measured by the kinetic energy of its molecules. Here we are dealing with a very remarkable case: we have a solid at the absolute zero of temperature in the midst of a medium of much higher temperature, and yet the solid (on account of the enormous pressure to which it is subjected) is unable to take up the surrounding temperature, but persists in its heatless state. If the pressure be released, the solid immediately regains the power of acquiring heat from neighboring bodies, and its temperature will rapidly rise from absolute zero until it reaches that of the surrounding material. It appears from the above to be a necessary consequence of the molecular theory that at a very great pressure matter must be reduced to a peculiar condition in which it will not obey the law of thermal equilibrium. Now the pressure at which this remarkable physical condition becomes manifest depends upon the nature of the material, and will alter with the temperature. As the temperature falls and the kinetic energy of the molecules becomes less, a smaller pressure will suffice to bring the molecules into contact. At ordinary temperature the pressures will be terrific—probably beyond our experimental power; but at very low temperatures a moderate pressure will probably suffice to bring about this condition. Pressure, however, is made up of two parts, external and internal, the latter being due to molecular attraction; therefore, even if the external pressure be zero, yet the molecules will be under a very considerable internal pressure, and the very interesting conclusion must be drawn that to this internal pressure alone there must correspond a definite temperature above absolute zero at which this new condition is induced in a substance. The usual assumption, therefore, that all substances can be cooled continuously and uniformly down to the absolute zero, is incorrect. At a minimum temperature depending upon the total pressure, the temperature of each substance will drop more or less abruptly and of its own

accord to absolute zero, no matter whether the surrounding objects be at absolute zero or not. The authors give a name, heat-point, to the temperature at which a substance will begin to vibrate its molecules under the influence of heat.

It should be added that the authors assume that rotary molecular motion would be stopped by pressure, and that they disregard intra-molecular vibration. Their deductions are based upon an entirely unproven assumption; but if it is a true one its bearing upon the condition of matter in the interior of the earth, for instance, is interesting.— *Chem. News*, lxxxv, 194. H. L. W.

2. *New Method for Assaying Pyrites.*—To determine gold and silver in ores consisting chiefly of iron pyrites, BUDDÄUS places 100 or 200^g, according to its richness, of the finely pulverized substance in a covered, smooth clay crucible and heats to redness in a muffle for one-half to three-quarters of an hour, until all trace of the sulphur flame has disappeared. The mass, which is loosely aggregated, is transferred to a dish or beaker of about 1000^{cc} capacity, any dust being removed by means of a camels-hair brush. It is then treated with 250 or 500^{cc} of a mixture of equal volumes of strong hydrochloric acid (free from arsenic) and water, and, after standing for about an hour in a warm place, the same quantity of the acid mixture is added, and the whole is boiled for some time. Ferrous sulphide, which forms the greater part of the ignited substance, is thus dissolved, leaving the gold and silver in the residue. When the sulphide is completely decomposed the liquid is diluted with water until the vessel is nearly full, and filtered. The residue is washed two or three times with water, then dried, transferred with the filter-paper to a Hessian crucible of 150 or 300^{cc} capacity, mixed by means of a spatula with 50 or 100^g of assay lead and 5 or 10^g of borax, and finally fused in a muffle. It is of advantage to use 100 or 200^g of a mixture of equal parts of acetate of lead and caustic soda instead of assay lead. After cooling, the crucible is broken, and the lead is cuppelled. Gold and silver are then parted as usual. The method appears to be more accurate and less expensive than those usually employed.— *Chem. Zeitung*, xxiv, 922. H. L. W.

3. *Germanium Hydride.*—VOEGELEN has discovered the fact that when hydrogen is evolved by means of sodium amalgam or zinc and sulphuric acid from solutions containing germanium, the gas contains a small quantity of germanium hydride. The hydrogen burns with a bluish-red flame which deposits a bright mirror upon porcelain. Mirrors are formed also when the gases are led through hot glass tubes, as in the Marsh test for arsenic. These have a tin-white color, and show a red color in transmitted light and a green color in reflected light. When the gases are passed through silver nitrate solution, a compound of germanium and silver is precipitated. Attempts to condense the germanium hydride by cooling the hydrogen with solid carbon dioxide and ether were without success, hence the hydride was not obtained in a pure condition. From the analysis of the precipitate pro-

duced by silver nitrate, and by another indirect method, it was shown that the gas probably has the composition corresponding to the formula GeH_4, corresponding to Winkler's tetraethyl compound $Ge(C_2H_5)_4$.—*Zeitschr. anorg. Chem.*, XXX, 325. H. L. W.

4. *Compounds of Beryllium with Organic Acids.*—LACOMBE has prepared a series of basic beryllium salts with a number of fatty acids. The acetate has the formula $(C_2H_3O_2)_6Be_4O$, while the formate, propionate, the normal and isobutyrates and the isovalerate have analogous compositions represented by the formula A_6Be_4O. The remarkable property of these salts is their volatility. The best means of purifying them is by distillation under diminished pressure. The formate is insoluble in all solvents, while the higher members become soluble, and may be recrystallized readily. The author was unable to prepare the normal salts of beryllium with these acids, such as $(C_2H_3O_2)_2Be$, while with strong mineral acids no salts of a type corresponding to the organic salts could be made.—*Comptes Rendus*, CXXXIV, 772. H. L. W.

5. *The Use of Floats in Burettes.*—An elaborate study of the use of burette-floats has been made by KREITLING. It was found that Erdmann's floats, as well as the so-called spherical floats, give irregular results in comparison with those obtained without the use of any float, and this was the case with different burettes and with floats of varying calibre. The causes of the variations could not be satisfactorily explained, but the conclusion was reached that it is not advisable to use any float whatever in a burette.—*Zeitschr. angew. Chem.*, XV, 4. H. L. W.

6. *Beiträge zur Chemischen Physiologie und Pathologie*, herausgegeben von Fr. Hofmeister. II Band, 4 Heft. Braunschweig, 1902. (Fr. Vieweg und Sohn.)—In an experimental study of the action of salt solutions isotonic with the blood, HAAKE and SPIRO have ascertained that even small quantities of such solutions slowly introduced into the circulation call forth diuresis. Sodium chloride solutions are peculiar in producing less marked effects. E. FULD has contributed a long paper on the reaction of rennin with milk, with particular reference to the relation between clotting-time and the quantity of enzyme present. The theory of rennin action is also discussed. In a second paper Fuld presents analyses of compounds of metaphosphoric acid with various proteids. While some of these synthetic products are quite constant in composition, they differ distinctly from the natural phosphorus-containing proteids. NEUBERG and HEYMANN report an investigation of the nature of the carbohydrate groups in the so-called pseudo-mucin of ovarial cysts, in which they have demonstrated that chitosamin occurs. L. B. M.

7. *Velocity of Light.*—The Decennial Publications of the University of Chicago, 1902, contain a suggestion by Professor MICHELSON of a new method for determining the velocity of light. The author reviews the previous results, contrasts the astronomical methods, the electrical and the optical methods, and proposes

a combination of the Foucault and the Fizeau methods. Instead of a revolving toothed wheel of Fizeau, he suggests the use of a stationary grating, and by a double reflection of light from stationary and revolving mirrors, and proposes to measure the eclipses the light suffers from the gratings. Figures accompany the original article which make the author's plan clear. He estimates that the velocity of light can be measured to a probable error of only 5 kilometers. J. T.

8. *Ultra-Violet of the Mercury Spectrum.*—HANS LEHMANN and R. STRAUBEL give a table of wave lengths, extending from wave length 221·31 to 193·04. They used the Berolina-Kupferdruckplatten of Gebhard, and developed with glycin. The apparatus consisted of an Abbe spectrometer, with collimator, prism and camera. Quartz fluor spar lenses were employed. The prism was a Cornu right and left quartz. The source of light was a Geissler tube with mercury electrodes.—*Ann. der Physik*, No. 4, 1902, pp. 909–911. J. T.

9. *A new Peculiarity in the Structure of the Cyanogen Bands.*—ARTHUR SCOTT KING gives a description of a band structure of the carbon arc spectrum, beginning at wave length 3465 and ending at 3274. Another band runs from 3203·84 to 3128.—*Ann. der Physik*, No. 4, 1902, pp. 791–800. J. T.

10. *Stationary Electric Waves.*—The subject of wireless telegraphy lends great interest to investigations upon the reflection of Hertzian waves from mirrors. K. F. LINDMAN has studied the subject under the following heads:

(1) The dimensions of the mirror were great in comparison with the wave lengths.

(2) The indicator was a resonator with a thermo element.

(3) The thermo resonator was rectilinear.

(4) The thermo resonator was circular.

(5) The indicator was a resonator with spark gap.

(6) The dimensions of the mirror were of the order of the wave lengths. An important conclusion is, that the parabolic reflector of the oscillator should not be shorter than the wave length, in case the focal length of the mirror is a quarter wave length.—*Ann. der Physik*, No. 4, 1902, pp. 824–850. J. T.

11. *Oscillatory Discharges.*—H. ANDRIESSEN calls attention to the importance of oscillatory discharges in the use of condensers. Such discharges often occasion greater ones than the calculation of tension, capacity, and periodicity would indicate, and therefore break down insulation which would resist non-oscillatory discharges.—*Ann. der Physik*, No. 4, 1902, pp. 909–918. J. T.

12. *Meteorologische Optik*, von J. M. PERNTER, Professor an der Universität in Wien und Director der Centralanstalt für Meteorologie und Erdmagnetismus. I. Abschnitt: pp. 1–54. Wien und Leipzig, 1902 (Wilhelm Braumüller).—The aim of this work is to present all that is known concerning the optics of the atmosphere, and, as no author has attempted the same task hitherto, it promises to be of great value. Part I treats in a clear and inter-

esting way of the apparent form of the sky, its causes and its consequences. It is to be shortly followed by three others, treating, respectively, of the phenomena due to the aeriform components of the atmosphere, of those due to the exceptional presence of foreign bodies (halos, coronas, etc.), and of those attributable to the constant presence of small particles. C. S. H.

13. *Instruments et Méthodes de Mesures Électrique Industrielles;* par H. ARMAGNAT. Deuxième Edition, revue et complétée, 599 pp. Paris, 1902 (C. Naud).—The first part of this useful book, constituting a half of the whole volume, contains a general description of the familiar laboratory instruments for electrical measurements and of their modes of use. Excellent features of the discussions are the statements concerning the limiting accuracy of the various methods. The second part, occupying about one hundred pages, is devoted to industrial appliances for electrical measurements. The remainder of the volume, constituting the third part, is given to a description of the methods employed in electric and magnetic measurements, both refined and industrial. It is in this part that the ordinary reader will find most that will appear novel to him. The volume as a whole is clearly written, clearly printed, and adequately, if not admirably, illustrated. C. S. H.

14. *Note on the Size of Nuclei;* by C. BARUS. (Communicated.) —If in case of nuclei produced by shaking solutions, we regard the nucleus as so constituted, that a central electron forms a closed field with the charge due to friction uniformly distributed* over the surface; if, moreover, the excess of vapor pressure at a surface of radius R is eventually equal to the electrical surface pressure, we may write $2T\rho/R = 2\pi e^2/(16\pi^2 R^4 K)$; whence $R^3 = e^2/(16\pi T\rho K)$, where e is an electron (7×10^{-10} electrostatic units), T the surface tension of water (81), ρ its vapor density (17×10^{-6}), K its specific inductive capacity (80). From this follows for the radius of the nucleus $R = 4{\cdot}5\times10^{-7}$, which (in the light of other data to be adduced at length elsewhere) seems to be a reasonable value. A nucleus smaller or larger than this will either grow or evaporate, respectively, to the critical radius here implied.

II. GEOLOGY.

1. *Geological Survey of Canada, Summary Report of the Geological Survey department for the Calendar year, 1901;* by ROBERT BELL, Acting Deputy Head and Director. 269 pp.—Since the death of the late director of the Canadian Geological Survey, Dr. G. M. Dawson, March 2, 1901, the administration has been in charge of Mr. Robert Bell. The appropriation for the year was $115,900. There were 31 parties in the field during the summer season, and 12 publications were completed and issued. Among the important investigations were those of

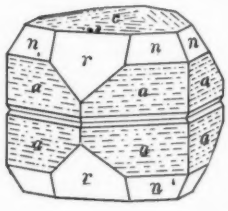
* As, for instance, by rotation.

McConnell in the copper regions of White Horse district; Leach and McEvoy on the coal basin of Fernice in the Crow's Nest Pass coal field; Dowling on the western side of Hudson, where rocks formerly represented as Laurentian were shown to be of Lower Cambrian age; Barlow on the Sudbury nickel and copper district; Adams on the Haliburton district; Chalmers on the superficial deposits of the interlake peninsula of Ontario exploiting for gas, petroleum and water; Laflamme made investigation of the Middle Silurian of Anticosti, bringing in numerous fossils; Bailey and Poole on the Carboniferous deposits of New Brunswick. These and many other lines of research are the steady progress of previous years. H. S. W.

2. *Field Operations of the Division of Soils;* report for 1900 by MILTON WHITNEY, Chief of Division U. S. Dept. Agriculture. 473 pp.; 51 pls.; 47 figs.; also 24 colored soil maps.—The work of the Division of Soils for 1900 covered a wide area. The eastern division, in charge of C. W. Dorsey, made surveys in Maryland, Pennsylvania, Ohio and North Carolina; the western division, in charge of Thomas H. Means, was at work in Utah, Arizona and California. 4,465 square miles were mapped on a scale of one inch to the mile. The laboratory work for the division included investigation on the physical and chemical properties of soils.

3. *The Mineral Wealth of the Black Hills;* by CLEOPHAS C. O'HARRA. South Dakota Geol. Survey, Bull. No. 3. Pp. 82; pl. 22.—Dr. O'Harra of the South Dakota School of Mines has described the economic mineral deposits of the Black Hills and includes in his treatise a general summary of the history, conditions, and apparent possibilities of their development.

4. *Corundum Twins;* by WM. E. HIDDEN. (Communicated.)—Crystals of corundum, gray and ruby-red in color, twinned parallel to the base *c* (0001), have been found sparingly in the "In situ" mine (of ruby, pink and gray corundum), Coler Fork of Cowee Creek, Macon County, North Carolina. They were first observed by the writer in 1898, upon crystals from a feldspar vein. The two best examples measure six millimeters in diameter and length. They are characterized by reëntrant angles (*n*, $22\bar{4}3$) on the prismatic faces (*a*, $11\bar{2}0$) and some slight natural corrosion. (See figure, drawn by Mr. John C. Blake of the Yale Mineralogical Laboratory.)



5. *Genesis of Ore Deposits;* published by the American Institute of Mining Engineers.—During the past few years several important papers on ore deposits have been published by the Institute of Mining Engineers. These have now been collected into a single volume. The first paper, from which the book takes its title, is the celebrated treatise by Franz Pösephny which was

given by him to the Institute in 1893. The other papers of the volume are entitled: Some Principles Controlling the Deposition of Ores, by C. R. Van Hise; The Secondary Enrichment of Ore Deposits, by S. F. Emmons; The Enrichment of Gold and Silver Veins, by W. Lindgren; Problems in the Geology of Ore Deposits, by J. H. L. Vogt; the Role of Igneous Rocks in the Formation of Veins, by J. F. Kemp; The Caliche of Southern Arizona, by W. P. Blake; The Character and Genesis of Certain Contact Deposits, by W. Lindgren; The Formation of Bonanzas in the Upper Portion of Gold Veins, by T. A. Rickard. Many of these papers have grown out of the discussion of Prof. Van Hise's original and valuable contribution. The different writers, with one exception, agree with him in his main conclusions. Prof. Van Hise has contributed a concluding chapter in which the chief points of the discussion are reviewed and summarized. A valuable appendix to the volume gives an index of all the papers on ore deposits which the Institute has published. W. E. F.

6. *Coal in Michigan, its mode of occurrence and quality;* by ALFRED C. LANE, State Geologist, constituting vol. viii, pt. ii, Geol. Survey of Michigan. Pp. 232, 9 plates and 9 figures. 1902. —The author discusses the origin, occurrence, analyses and tests, erosion and disturbance and development of Michigan coal. As to the geological horizon of the coal seams he makes the following statement, based upon paleontological analyses made by Messrs. Girty and David White of the U. S. Geological Survey, viz: "All the indications are that all our series are low down in the Coal Measures (Mesocarboniferous), in fact in that section of it known as the Pottsville formation, 'seral conglomerate' or 'millstone grit' a part of the series which was once supposed to be below any important coal seams, though it is now known that some of the best coals of the United States, the Lykens Valley of Penn., the Pocahontas and New River of West Va., the Sharon Marsillon and Mercer Coals of Ohio, belong to this series (p. 41). H. S. W.

7. *Adephagous and Clavicorn Coleoptera from the Tertiary Deposits at Florissant, Colorado;* by SAMUEL H. SCUDDER. U. S. G. S. Monograph XL, 148 pp., 11 pl., 1900.—This is a second instalment toward the history of fossil coleoptera, the first of which was published in 1893 as Monograph XXI, and contains an account of the non-rhynchophorous coleoptera of North America, 210 species of which are now known belonging to 26 families and 125 genera. The beautiful plates illustrate the new species; and in their proper places all the species of each genus are recorded, thus giving a summary of present knowledge of the extinct forms of the groups considered. H. S. W.

8. *Acrothyra and Hyolithes—a Comparison; Hyolithes gracilis and related forms from the Lower Cambrian of the St. John Group; A backward step in Palæobotany;* by G. F. MATTHEW. Trans. Roy. Soc. Can., vol. vi, section iv, pp. 93–122. —Dr. Matthew believes that the Pteropoda and the Brachiopoda

may have originated from the worms. He also believes that Dawson was correct in ascribing the plant remains near St. John to the Devonian.

9. *Ostracoda of the basal Cambrian rocks in Cape Breton;* by G. F. MATTHEW. Can. Record Sci., vol. viii, No. 7, pp. 437–468.

10. *Fossil Mammals of the Tertiary of Northeastern Colorado;* by W. D. MATTHEW. Mem. Amer. Mus. Nat. Hist., Vol. i, Part vii, pp. 355–447, 1901.—This extensive memoir upon the fossil mammals of the Oligocene and Loup Fork beds of Colorado contains much that is new, interesting, and important to the student of paleontology, and is a notable contribution to the extinct mammalian fauna of this country. That which is perhaps the most novel feature of the paper, however, is the conclusion that the unlaminated clays of these beds are of eolian origin, and that the sandstones and laminated clays represent river deposits accumulated upon a flood plain. The old view of the lacustrine origin of these sediments which has been held by all the leading geologists of this country for many years past, is regarded as untenable and is rejected. The evidence which the author regards as in favor of this hypothesis is classified and considered as follows: (A) The Stratigraphic Evidence, under which are grouped (1) objections to the lacustrine hypothesis on account of the size of the supposed lake, and the absence of distinct terraces; (2) great thickness in the west near the mountains, with gradual thinning out to the eastward, is thought to be evidence in favor of flood plain action rather than deposition in a lake; (3) the manner in which coarse beds are intercalated among the fine sediments, if lacustrine would indicate "frequent, spasmodic, and extensive changes in the level of the lake"; (4) the absence of thick marginal deposits and the character of the erosion of the sediments are opposed to their lacustrine origin; (5) absence of conglomerate beds at the base of the formation; and (6) lack of lamination of much of the clays, are all thought to be opposed to their disposition in a lake. (B) Paleontological Evidences. These are held by the author to be much more convincing than those derived from the stratigraphic arguments, and he does not hesitate to affirm that, "The burden of proof that climatic and geologic conditions were so widely different from modern times as to sustain a huge inland sea of fresh water in the now arid Plains, lies not with the opponent but with the exponent of the lake theory." The argument derived from the paleontological evidence consists, according to the author, of the fact that the fauna of the clays is a strictly terrestrial fauna, and different from that contained in the sandstones. The fact that there are no aquatic invertebrates, fish, aquatic reptiles or mammals, but large numbers of land tortoises, together with peculiarities of occurrence and preservation of the fossils contained in the sediments, are believed to place insuperable difficulties in the way of a belief in the lacustrine origin of these deposits.

In order to examine the arguments therein set forth even in the most imperfect manner, would require a greater amount of space than is possible to devote to a brief review of this kind. I can therefore mention only a few of the more important objections which can be urged against this hypothesis. They are as follows: (1) If the absence of lamination in clays is proof of their eolian origin, then we must suppose that all of the unlaminated clays of the Jurassic, Dakota, Laramie, Puerco, Wasatch, Wind River, Bridger and Uinta, have been deposited in the same way; but there is abundant and incontestable proof that many such beds, at least, were laid down in water; otherwise how can we explain the presence of aquatic invertebrates? (2) sticky, plastic clay, of which much of the White River deposit consists, is not easily moved by the agency of the winds; (3) all the phenomena of deposition of these sediments can be more easily and fully explained by delta action, with its ever present flood plain accompaniments, and has, moreover, the advantage of much greater probability and plausability; (4) it is extremely doubtful if any flood plain deposits are now being made, except in the vicinity of the mouths of rivers where they empty into an ocean, sea or lake; (5) our knowledge of the habits of the extinct mammalia is yet too imperfect and lacking in exactness to afford in itself a very secure foundation upon which to build profound geological theories; (6) the oligocene deposits of the Laramie Basin, presenting the same lithological characteristics and containing the same mammalian fauna as those of the Plains, are surrounded by well-defined mountain barriers; they contain abundant remains of fishes in the clays, as well as other very convincing evidence of their lacustrine origin. Much other evidence could be cited, but lack of space forbids.

The paleontological part of the work is well presented and contains many discoveries of importance. Among these may be mentioned the additional characters of the curious sciuro-morph rodent *Mylagaulus*, the skull and jaws of an extinct marten, an extinct mole, the first ever found in the American Tertiaries. A new and plausible explanation of the probable uses of the enlarged canines of the saber tooth tigers is also given. Some large giraffe-like camels are described and much additional detailed information of many groups presented. The announcement that Primates are absent in the American Oligocene had been made by the reviewer nearly two years previously. J. L. W.

11. *Pleistocene Geology of portions of Nassau County and Borough of Queens;* by JAY BACKUS WOODWORTH. N. Y. State Museum, Bull. 48, pp. 618–666, 9 figs., 9 pl.

III. Botany.

1. *Recherches sur le développement du tégument séminal et du péricarpe des Graminées;* by Paul Guérin. Paris, 1899.—The structure of the pericarp and the seed-coat in the *Gramineæ* is a subject that has not been studied very much hitherto, and it seems as if most authors have confined themselves to the study of those genera or species as are of purely economical value, the Cereals for instance. The results of these studies are, however, very diverse, so that we have not reached any definite conclusion as to the real structure of the pericarp and seed-coat before and after fecundation has taken place. Nevertheless the Gramineæ have recently been classified under Van Tieghem's "Inséminées" on account of some observations made by Jumelle, who claims that both the external and internal integument of the ovule in the Gramineæ become reabsorbed after fecundation; thus the fruit develops as an achænium, enclosing a seed with no seed-coat. This statement is very much in opposition to the explanation given by Kudelka and Johannsen, who arrived at the conclusion that only "the external" integument becomes reabsorbed, while the internal integument persists and grows together with the pericarp.

Not until a few years ago has the subject been taken up again by Dr. Guérin, but this author has not confined himself to studying Cereals alone, but has examined a number of representatives of each of the thirteen tribes which are generally recognized as constituting the order Gramineæ. The structure of the pericarp and of the integuments of the ovule has been studied very carefully and compared with the final composition of the fruit and seed-coat after fecundation. Several very instructive illustrations accompany the anatomical sketch, and show very plainly the changes that take place in the ovary before and after the fecundation of the ovule. But the results gained by Dr. Guérin's painstaking studies are not in accordance with those presented by Jumelle, thus there seems to be no foundation, so far, for classifying the order among the "Inséminées."

To do full justice to this important work of Dr. Guérin, it would be necessary to give a detailed account of all the facts, as presented, and we regret that the space assigned does not allow more than a brief abstract of some of the results; we must refer to the paper itself for further details. The author confirms the observations of Kudelka and Johannsen, that only the outer integument becomes reabsorbed after fecundation has taken place, and the formation of the seed-coat is, thus, solely due to the persistence of the inner integument. The mature seed is invariably surrounded by a seed-coat, even if the inner integument may, sometimes, become partly reabsorbed, but never completely so. The inner integument consists generally of one or two layers of cells, and the innermost layer is, as a rule, the

highest developed and acquires large dimensions in some genera, viz: *Uniola, Phœnosperma*, etc. The seed-coat is closely adherent to the pericarp in the *Gramineæ* with the exceptions of *Eleusine, Dactyloctenium* and *Zizaniopsis*. The epidermis of nucellus may, also, persist as a hyaline covering or it may be developed much further and serve for the protection of the seed, as in *Bromus* and *Brachypodium*. The fruit is an achænium in *Eleusine, Dactyloctenium* and *Zizaniopsis;* it is a somewhat modified caryopsis in *Sporobolus* and *Crypsis*, but in all the other genera examined the fruit is a true caryopsis. A seed-coat is, thus, always present, but the structure is often obscure and not readily perceived, unless the tissues have been studied at the younger stages of both fruit and seed. T. H.

2. *Alpine plants from Tibet and the Andes.* Abstract of a paper by W. B. Hemsley and H. H. W. Pearson, read before the Linnean Society. (Journ. of Botany, London, 1900, vol. xxxviii, p. 238.)—Students of alpine floras may be interested to learn that in Central and Northern Tibet, at an elevation of from 15,000 ft. to 19,200 ft. above sea-level, the following orders predominate: *Compositæ, Leguminosæ, Cruciferæ, Ranunculaceæ* and *Gramineæ*. At 19,000 ft., the greatest altitude on record for flowering plants, Deasy and Pike have recorded: *Corydalis Hendersonii, Arenaria Stracheyi, Saxifraga parva, Sedum Stracheyi, Saussurea bracteata, Gentiana tenella, G. aquatica*, an unnamed species of *Astragalus* and of *Oxytropis;* at a lower elevation, c. 17,000 ft., *Allium Semenovii* was found in great abundance.

In the Bolivian Andes, Sir Martin Conway collected 7 species from 18,000 ft. or above, two being as high as 18,700 ft. These, the highest Andine plants on record, are: *Malvastrum flabellatum* Wedd. and *Deyeuxia glacialis* Wedd. 39 species were observed above 14,000 ft., and these belong to 34 genera and 21 orders, of which 15 are included in the *Compositæ;* of the 34 genera, *Blumenbachia* is the only one that is endemic to South America. T. H.

IV. Miscellaneous Scientific Intelligence.

1. *Smithsonian Institution Publications.*—The following papers form parts of vol. xli of Smithsonian Miscellaneous Collections:

Index to the Literature of the Spectroscope (1887–1900 both inclusive); by Alfred Tuckermann. Pp. 373.

Bibliography of the analytical Chemistry of Manganese (1785–1900); by Henry P. Talbot and John W. Brown. Pp. 117.

Chemical Societies of the Nineteenth Century; by Henry Carrington Bolton. Pp. 15.

2. *United States Coast and Geodetic Survey. Annual Report 1900;* by O. H. Tittman, Superintendent. 712 pp., with numerous maps and illustrations.—The field work of the Coast Survey during 1899–1900 was widely distributed over the United States,

and parties were sent also to Alaska, Porto Rico, Hawaii, and the Phillipines. Appendixes to the report include: The Boundary Line between California and Nevada; The International Latitude Service in Maryland and California; Outlines of Tidal Theory.

3. *Die Fortschritte der Physik im Jahre 1902. Halbmonatliches Litteratur-verzeichniss;* redigirt von KARL SCHEEL (reine Physik) und RICHD. ASSMANN (kosmische Physik). Braunschweig, 1902 (Fr. Vieweg und Sohn).—Numbers 6, 7, 8 (pp. 117–175) have recently appeared. See note in this Journal, vol. xiii, p. 319.

4. *Elementary Calculus;* by PERCEY F. SMITH, Professor of Mathematics in the Sheffield Scientific School of Yale University. 12mo, 89 pp. (American Book Company).—The design of the author is to give in the compass of from thirty-five to forty ordinary class-room exercises a thorough knowledge of the essentials of the differential and integral calculus, together with sufficient practical applications to exhibit the scope of the subject and furnish the student facility in the use of his tools. Such a course will be a wise economy of time for many students, and will bring a knowledge of this great science to many others who would never undertake to master a more formidable treatise.

W. B.

5. *Prize for Scientific Work by Women.*—The Association for maintaining the American Women's Table at the Zoological station at Naples and for promoting Scientific Research by Women, announces the offer of a second prize of one thousand dollars for the best thesis written by a woman, on a scientific subject embodying new observations and new conclusions based on an independent laboratory research in biological, chemical or physical science. Theses must be presented before Dec. 31st, 1904, to Mrs. Ellen H. Richards, Mass. Inst. Technology, Boston, Mass.

OBITUARY.

HENRY MORTON, President of Stevens Institute of Technology, at Hoboken, N. J., died May 9th at the age of sixty-six years.

M. ALFRED CORNU, the eminent French physicist, since 1867 Professor at the École polytechnique in Paris, died in April last at the age of sixty-one years.

DR. ALEXANDER BITTNER, chief geologist in the Imperial Geological Institute at Vienna, died recently at the age of fifty-two years.

M. HENRI FILHOL, Professor of Paleontology at the Jardin des Plantes, Paris, died recently at the age of sixty-eight years.

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